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*EDITED BY J. McKEEN CATTELL*

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THE SCIENTIFIC MONTHLY

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# EARTH SCIENCES AS THE BACKGROUND OF HISTORY[1]

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## The Larger View of History

THE concept of history as generally accepted has undergone extraordinary changes in recent years. History as read and taught has frequently expressed only in part the broader relations of events with a view to indicating their true bearing on the present. In its origin as a constructive science much of history was concerned with the emotional side of national propaganda, and in varying measure it has been an instrument used to promote a nationalistic spirit. Fortunately, we find many interpretations which have clearly stated the continuity of events, their real relations and significance in the world sense, and their proper trend.

Not less insufficient than the use to which history has often been put is in many instances the structure of the account presented. Continuity has not always been the fundamental factor. Descriptions of events in series, but unrelated, have at times formed the basis for discussion, and fundamental laws or scientific principles have not always played an important part.

Reaction against the incomplete view of historical study is in some measure due to application in human affairs of the hypothesis of evolution or development growing out of the fundamental historical sequence of geology as presented by Lyell and applied in the broad biological concept of Darwin. Assuming that man remains on a constant level, representing the type as created, human history might show indefinite fluctuations of movement; or it might be cyclic, each cycle representing approximately the same plane of development. According to the evolution hypothesis, the trend of the living world would be toward the more specialized, or more complicated, or more advanced. Although it might be cyclic, each cycle would rise to a

[1]Delivered as the Presidential Address before the Geological Society of America, December 29, 1919.

higher stage, and the path would be helicoid. According to the developmental or evolution interpretation, every part of a historic sequence is related to every other part, and each feature of past series contributes somewhat to the interpretation of the present. This concept gives us for every portion of historic succession a formula, through which, with a certain degree of accuracy, the line may be projected forward. Viewed in this light, history becomes not merely a teacher by comparison or by analogy, but interprets the development of present conditions, and also furnishes a key to the future.

Rarely has the range of historical account included all major influences actually involved. Largely by reason of the fact that the world is so complicated, there is no connected statement which shows the happenings as a whole with their interlocking connections. The records are mainly pieces, or pieces of pieces, limited to one phase of the subject, restricted to one portion of the world, and covering only a small section of time. True world history scarcely exists.

Analysis of the elements composing the fabric of history, considered in its enormous complication and as a world problem, shows that we cannot doubt the need for every item of knowledge which may be brought to bear for interpretation of our present situation and requirements. We must have these materials also for guidance of mankind in decisions on those greater problems demanding for their proper settlement a vision reaching over long periods and extending beyond the present generation. We should have light with increasing brilliance thrown into many dark corners.

Present world questions will be solved in part by men who trade and those who study commerce, in part by men who rule and those who study ruler and politician. But the only view that can show us where we are and whither we go is one that, with other items, includes at least the outlines of the path over which we have come.

The point of my story in this paper is that the farther back we see the path clearly, and the better we know our progress over it, the more certain we are to eliminate the minor curves and determine the true direction and the rate of speed to expect.

I am suggesting that the deepest view of history is desirable for the purposes of fundamental decisions; that, no matter how far back this vision leads us, if it continues to add to knowledge of what we are by showing us how we came to be, it is needed and should be secured.

### Contribution of the Sciences to History

The sciences especially concerned with historic sequence are astronomy, geology, geography, paleontology, biology and anthropology. Astronomy, with its broad conceptions of stellar evolution, concerns us because it discusses the origin and early history of our planet. Geology

and geography deal directly with the earth. Paleontology, representing biological history, must go to geology for its record. Anthropology has, as one of its most important phases, the history and origin of man.

The field of the astronomer, with its myriad bodies of the heavens, presumably represents wide range in development of the stellar systems within our view. Yet, with all our information as to the stages through which these bodies may proceed in their history, there is but little positive evidence on which we may depend. We may note modifications in the surface of the sun or in the clouds of Jupiter, or we may observe the varying brightness of the stars; but there is little in these variations which we have proved to be more than incidental fluctuation. Our knowledge of evolution of the stellar universe must depend largely upon comparisons of stars of various types, or of groups of stars and nebulae which we assume to represent incipient stellar systems. The nebular hypothesis, which has served to present a type of evolution of the solar system and a basis for interpretation of the origin of the earth, is called in question to such an extent as to be no longer acceptable to a large group of astronomers. The planetesimal hypothesis, developing similar world systems out of spiral nebulae, seems also to suffer under recent criticism. For practical comparisons in study of world evolution, we appear to have one of the most important sources of information in the history of our own planet. For the universe in the large we can prove little more than that there is shown a process of development for which almost infinite time seems required and in which cycles seem determined.

Our greatest scientific contributions to the study of history and of origins have come through geological and biological investigations. Geology is the greatest of historical sciences. From comparative and experimental studies alone biology makes large contribution, but its distinctly historical phase lies in the field of paleontology, in which the life record is read from the geological book. To geology and biology, furnishing together the life records, anthropological history must be added, reaching back, as it does, into geological history and expressing the beginnings of our account of human life and activity in terms of geology and paleontology.

For the purposes of this paper, geological history may be divided roughly into two portions. One, the later division, is represented in the known section of stratified rocks formed through the piling up of sediments and by the out-welling of molten material spread on the surface or squeezed into the strata. An earlier period expresses in a more doubtful manner the partly astronomic history of the earth antecedent to the record presented by the lowest or earliest known strata.

The astronomic period of our earth's history is a subject for investigation by astronomer, physicist, chemist, and geologist. As yet the results of studies in this region are in large part of a speculative nature. The field furnishes one of the most attractive opportunities in science for further investigation. Although this phase of the problem has in it very much of fascination, the results are still of such a nature as to contribute little toward the objects of the present discussion. I shall therefore refer to geologic history only in terms of the distinct record extending to the lowest known strata in the second chapter of the account.

The length of the period which remains after elimination of the earlier or astronomic stage may be very short measured against the total age of the earth. We know that the lowest strata, wherever we find them, rest upon rocks which have been molten and in their molten state have destroyed the basement upon which the oldest known stratified rocks once rested. We admit, therefore, that not only have we lost the record before the earliest strata were formed, but that the earliest strata themselves have disappeared. The record remaining is, however, by no means brief in terms of human understanding. Few recent estimates have suggested that the section comprises less than two hundred thousand feet of strata, or that the time involved measures less than one hundred million years. This time may not be long compared with the entire age of the earth, and may not be more than a moment compared with the age of our solar system, but it furnishes all that we require for purposes of interpretation of human history.

Reduced to their simplest terms, the geological data of the stratified rocks give us a history relating to the accumulation of sediments, movements of the earth's crust, the making of continents and ocean basins, erosive agencies tending to wear down the land, volcanic activities, climatic changes, and life succession. This history presents, as its first significant lesson, the fact of instability of the earth's crust and the evidence that throughout geologic time, as we know it, the surface has shown diversity of form dependent upon movements of large magnitude. By offering opportunity for erosive forces to act, the movements which have produced continents and mountain ranges have also been responsible for accumulation of the sediments washed down to form the strata from which our record is read. Also intimately related to the succession of crustal movements is the history of igneous activity evidenced from time to time in the great extrusions of molten material forming successions of lava flows intercalated in the sedimentary series. The history of climate, furnished us through a great variety of data, gives evidence of almost continuously fluctuating conditions in the physics of the atmosphere, ranging between high and low humidity, and between temperatures comparable with those of the glacial periods and the climate of tropical or subtropical

regions of the present day. The salient features of climatic history are the continuous change and the evidence of comparatively slight range of temperature for the earth as a whole within the span of geologic time as known.

Earth history, as we see it in this record, shows from the most remote periods to the present constantly varying surface conditions dependent upon an unstable crust; continents and mountains arise only to be subject to the steady grind of erosion, wearing them away and spreading the débris over the seas. Always do we find land areas and seas, but with much variation as to size and form; always was the temperature near that of the present, though fluctuating from warmer and more humid to climates like that of the Glacial Period.

Within the whole span of geological history and its continuous changes recorded, the phases of purely physical history presented do not show us in any of their various aspects definite progression or trend which may be described as an evolutionary process. It was once our practice to place emphasis on the geological history of the earth as the continuation of a graded or evolution series based on the succession of stages described in the nebular hypothesis. According to this view, we seemed to see in climatic evolution a gradual movement away from the conditions of the primitive heated earth and toward the present temperature of a cooling sphere. We once thought we saw the early atmosphere fit only for lower organisms and later cleared and purified for the higher types of life. With better understanding of climatic history, it comes out more and more distinctly that while the earth's climate fluctuated continuously, there is no clear evidence of definite progression through a series of stages dependent on gradual cooling of a once highly heated globe.

So in other phases of purely physical history we have worked out what seemed at first to be evolution series, which have all proved finally to be nothing more than cycles that may be represented by variable formulae. As nearly as we can determine, the physical history of the earth within the span of time represented by our legible record has been so nearly stabilized as to show little or no variation which may not be considered merely as fluctuation rather than as evolution.

As evidence of a continuously changing evolution series, the most extraordinary record of all history is that included in the paleontologic succession of life, running down through the story of geology, practically to the beginning.

Not only do we find the character of the earlier stratified rocks indicating atmospheric and climatic conditions similar to those now obtaining on the earth, but we find the rocks containing traces of living forms such as now are fitted to these climatic conditions. Throughout the whole stretch of the strictly geologic record, conditions in temperature and humidity evidently kept within the range

permitting development of living forms. The period in which life came to be on this earth is represented by a chapter now obliterated.

The life record is, to be sure, fragmentary, but in many groups it is extraordinarily full. Although there is much to be desired, out of the long series of events certain features in the evolutionary sequence are so clear as to be unavoidable. We find this record showing: (1) that life has been in almost continuous state of change. From top to bottom of the geologic section, in no two great groups of strata do we find that the assemblages of living forms represented are the same. (2) We know the life of each stage to exhibit closer resemblance to that found in strata immediately above and immediately below than to the life representation of the more remote divisions. And (3) we note that the series of forms with certain common characters, but differing in grade of specialization, generally trend toward greater specialization from earlier toward later time. The way in which the changes in living forms took place from age to age may not always be evident, and the paleontologist may admit his ignorance of the causes, but the fact of more or less rapidly changing, definitely specializing series of presumably connected or related types seems reasonably clear. The evidence, taken in its entirety, furnishes strong support for the view that the life of each stage is derived or modified from that of a preceding stage, and that the whole series indicates the continuity of life from earliest to latest time.

Unlike the sequence in purely geologic history, we have in the paleontologic succession continuity with progress in a definite direction. We have, however, noted that there is probably close relation between the continuous change of the progressing living world and the fluctuations in condition of earth climate and earth crust. Movements of the crust producing change of topography and variation in distribution of land and water, taken with changes of climate, must have had important influence in keeping the currents of life moving. A dead earth, without crustal movement and with uniform climate, might have limited greatly the possibility of biological evolution. The fluctuations in physical conditions on the earth in geologic time have, therefore, great significance in consideration of the larger problems of earth history.

It is not my purpose to bring into review, or to discuss, the tremendous field for evolutionary studies in the history of groups of animals and plants whose records we find preserved in the rocks. One after another these series have been considered by specialists in various fields. In all cases, the laws of which I have just spoken find expression, whether this be in the evolution of nautilus, dinosaur, or elephant. Given lapse of time and change of environment, and the old goes out, the new comes in, the unspecialized gives way to the specialized. As the ages go by, in each successive step, almost without

exception, we find a higher level of life, representing greater intelligence, greater efficiency, and greater progress.

The most interesting of all the series of fossil forms represented in the geological record, and particularly interesting in the first instance because it begins well back in past time, is that succession giving us the beginnings of the race of man. The earliest known traces of human beings represent a normal part of the life of the earth in a period so remote from the present that our calculations must be in terms of eons rather than of millenniums. We find that since these first man-like forms appeared great crustal movements have changed the face of the earth, and that the climate has shifted back and forth many times through relatively wide ranges of temperature. We know also in this period a long procession of living generations of animals other than man passing through the ages and disappearing.

We find the first remains of humans more beast-like than any living race, approaching the ape-monkey group in many characters, and meeting the requirements of the missing link. We find this first stage followed by others still different from man of the present day, but approaching more nearly to the modern type. The laws applicable to the evolution of other groups apply to man. We note the same relation of physical change in man to lapse of geologic time, to climatic and crustal change, and to other factors in the history of the earth. So far as the evidence goes, it meets the requirements of those who assume the emergence of man from the animal in the manner in which innumerable other organic types have arisen in the long life record as we know it.

Through still later stages of the geologic and paleontologic record man advanced in intelligence and culture, his environment gradually approximated present conditions in both physical and biological factors, and we record the history of these stages partly in terms of archeology, which in turn merges into history based on written records.

Through the evidence of archeology, paleontology and geology we see human history extended back stage by stage until we go from history to prehistory, where in ages remote and in environments strange we find man already widely distributed over the earth, varying as to kind and culture and advancing as to ideas. With this view there seems no escape from recognizing that not merely the foundations of history, but the greater part of the human span, falls within a realm the approach to which has been largely by investigators concerned with the problems of earth science and using the methods developed for this field of study.

The present paper is addressed to the relation between this material, obtained from the earlier segment of history which has been briefly outlined, and that which comes within humanistic study based on modern man. You may perhaps urge, as in Huxley's remark con-

cerning the significance of information obtained through a "medium," that, whether or not we are truly dealing with "a message from beyond," there may not be in what we learn anything worth attention. It may be thought that remoteness means by definition diminution of value and interest, and that events of ancient history diminish in importance as the square of the distance, or at a more rapid rate. At present my only answer would be that what is first is commonly, if not always, fundamental, though fundamental characters may be overshadowed by superficial.

It is not my purpose to give detailed illustration of present and future use for the facts of history seen in outlines of the longer span secured by study of earth sciences. I may, however, set forth one or two examples.

Of the many elements in the problem of world government which now confronts us, there seems to me every reason to believe that race as a fundamental factor is inferior to no other involved in consideration of unity in organization. Assuming that culture, speech, economic interest and political organization may temporarily overshadow it, in the last analysis we may not avoid reckoning with this factor, not merely in consideration of the organization of the greater groups of human beings, but also in the relations of slightly separated types. The fact that we may refuse to consider it does not prevent its acting as a continuously operating element, which remains while prices go up and down, political parties come and go, and national units group themselves in this way or that.

Race is the product of evolution in a changing environment the conditions of which have been determined by factors of geological significance. As a relatively simple illustration, the history of the original Americans is a tangled web in which is inextricably woven the story of great continental and climatic changes and of vast intercontinental migrations of plants and animals. The history of European and Asiatic races is of like order. The relation between Africans and Caucasians or between Africans and Mongolians is dependent on similar conditions reaching into remoter periods and still more difficult of interpretation.

The Balkans represent the fault-line of Europe, because this is a region of overlapping races and subraces, conditioned in their history by extraordinarily complicated migrations determined and directed in part by physical features and climatic changes. Although the Balkans present a problem of the greatest difficulty in the racial and political sense, they place before us a study simple of aspect and significance compared with the larger race questions which we shall encounter in consideration of world government. The difficul-

ties of this problem we shall not improbably see in larger measure as the centuries pass.

Shall we, in attempting to solve these incalculably complicated questions, look only at the present balance of trade, the dominance of particular political parties, the present grouping of social elements, or the present military strength of the nations involved; or shall we, realizing the vastness and the complexity of the difficulty, bring to the light every element concerned, scrutinizing with especial care those factors which seem to be fundamental and more clearly of permanent significance? Unless the larger or broader view is taken, I feel that we shall fall short of the interpretation of humanity needed in order to fit the nations of the world together into one great unity in which each people supplements the needs of the others, and thus gives to every group, as well as to every individual, the freedom to develop its own peculiar talent and grow into that fullest usefulness which we assume to be the natural right of all.

The question of race just described is only one phase of the historical problem in which the background represented by earth sciences becomes of real significance.

In passing, I may mention only two other examples illustrating the relation of historical data from earth sciences to affairs of life of today. I believe I am correct in stating that earthquakes are by most persons considered as extraordinary happenings, without relation to the normal order of events with which we have acquaintance. The geologist, however, recognizes them as the natural corollary of crustal movements. Regarding the continuance of such movements, he must believe that the only basis for considering that crustal activities have ceased is to assume some extraordinary intervention definitely holding back forces which if unfettered would result in further crustal disturbance and in earthquakes. Such disturbances have affected the earth since the beginning of our geological record. The geologist who views the history of crustal movement considers that there is no reason for believing that the crust is now stabilized, and assumes that we may expect other movements and other earthquakes. We know fairly the physical laws that govern earthquakes. We can prepare to meet them in such a way as to eliminate most of the dangers incident to their action, but it will take the passing of another generation before we reach a stage in which the clear lessons of earth history bearing on interpretation of these phenomena will become the basis of common practice, such as dictates the precautions which have made it possible for us to build in summer against the rains of autumn and the snows of winter. Many of us still build as if the last earthquake suddenly ended the series measuring back for tens of millions of years.

Still more difficult may it be for us to make use of the lessons of pre-historic history relating to our adjustment to biological environment. In America we live largely on plants and animals of Old World origin, not because the abundance of these types is so much greater than that of American, but because man has lived a longer time in the Old World, and within the period of his early history, reaching back to past geological periods, he has experimented intentionally or accidentally with Old World plants and animals for a longer time than has been given to contact with the native life of America. There are many who do not recognize this relation to the world of undomesticated organisms about us, and seem to feel that some plants and animals were predetermined to domestication, while others can never serve us.

Left to chance, as during the past millenniums, we may in time develop a series of useful American plants and animals corresponding to those of the Old World; or, recognizing the significance of the historical explanation of our relation to domestication, we may be active and carefully directed research secure results comparable to those of a long period of casual or accidental contact, and obtain a great variety of wild forms for use to meet human needs. Such an example of possibilities seems to be found in the development of the desert rabbit-brush as a source of rubber. An investigation was undertaken as an emergency problem during the World War, when there loomed before us the possibility that submarine dominance would eliminate all possible rubber importations. Recent studies by Hall and Goodspeed have shown the presence of 300,000,000 pounds of rubber in the desert region of the West. At present prices it is not available. In an emergency it might be a factor of first importance contributing to defense of the nation. Future research may also show possibility of large use of this supply through cultivation of the wild stock, thus making the desert an important area of production.

History shows us that sufficient understanding of the natural world about us brings large contribution to human comfort and efficiency; but, in spite of the lesson before us, many feel that the day of discovery of species most useful to man is past.

Returning to the larger view of our problem, the value of ancient history depends on our breadth of interest. If we are to deal only with matters of limited personal or national significance, only for immedate ends, and without reference to other generations; if our democracy is circumscribed in space and time, then lack of perspective and of fundamental laws in history may not be felt. If, on the other hand, we see the impending necessity of full understanding of the world's needs in their present relations and future complications, it behooves us to increase the range of human knowledge and of our comprehen-

sion of all factors entering into the problems. To most of us it appears that these great questions require the widest and deepest possible range of human understanding and the labor of generations for their satisfactory adjustment. The world statesman of the future must not only be trained to larger and higher vision, but he must have available an organization of knowledge perfect in its simplicity and infinite in its detail, covering every interpretable phase of the intricate human problem. As we approach the assembling of the data required we recognize at once the limits of the human mind and of human life, and accomplishment seems realizable only through operation in an altruistic democracy, making possible intellectual co-operation covering a wider range of experience than can be available to the individual mind.

If, in consideration of the larger problems suggested, we assume that man was created as we find him and destined to no higher plane, the sequence of history is of little value. If, however, the evolutionary view of life be correct, the continuity of history becomes of great importance, and origins, however far back, interpret the present. Should we recognize man as the product of a long series of changes determined by laws laid down in the record of earth sciences, we would have reason to consider every fact in his history as bearing on his present situation. In this interpretation of the record we view history feeling assured that nothing on the earth or in life stands still, and that the movement means continuous lifting of the plane to the more complex and more progressive.

In the lines which have been read it has been my purpose to indicate the extension of history backward into the earth sciences, and to point out the significance of this sequence as a continuity presenting in its formula an expression of the present. One may not leave the subject without referring also to the possibility of extending this continuing series from ancient geologic time into the future through a span comparable to the past we know.

To one who views the story of the world as presented through the medium of the earth sciences, it must seem unnatural to conceive of the physical and biological forces now in operation as ceasing to act before lapse of many periods like those which we have viewed. Unless there intervenes some extraordinary force beyond the reach of our understanding, the laws which have so long defined the course of nature must continue operation. Without the addition of any power beyond the spring of action furnished by laws now working, the clock of the universe must go for almost infinite ages.

Just as we are not able to conceive of crustal movements ceasing so long as we are subject to physical forces like those now controlling nature, so when we visualize the history of life in the broadest sense

we are unable to understand how the biological world, if it continues to be, and if it continues in the environment of physical change, can do other than go on to greater extremes of specialization, to greater range of complication, to greater comprehension, and to greater intelligence. If man of the future continues to maintain the relation between mental and biological which has obtained in the past stages of his evolution, there is reason to believe that he may reach to heights of mental ability, of comprehension, of intellect, of understanding, greater than those yet known. What the ultimate goal will be no one may yet see; without fundamental change of governing laws, the movement must go on.

### The Geologist's Rôle of Interpreter

One does not expect a geologist to state his views in philosophy or in phrases aiming at the deeper human understanding, and yet there seems reason for feeling that the wider outlook of science in all of its aspects lifts us up to the identical viewpoint from which the philosopher and the poet obtain their comprehensive vision. Unlike the philosopher we do not reach backward to explain the origin or forward to interpret the ultimate purpose of Nature; nor can we, like the poet, picture in words with fullness of meaning the view which opens to us; but the type of landscape spread before us and the training of the eye which sees it give to our picture a measure of reality which its stupendous magnitude does not lessen.

Of all favored men the geologist and paleontologist see the panorama of the past unrolled in clearest reality. To them the life record is not written in doubtful hieroglyphs and symbols. It represents the imprints of living feet that have never ceased to advance in unbroken procession over a trail that winds upward through the ages. From one glimpse at footprints on these sands of time, a poet, in the person of Longfellow, gave to all generations a Psalm of Life, which has found response in an ever-widening circle of human hearts. Longfellow's poem, suggested by the antiquity of the print of a foot upon the Connecticut sandstone, was based upon a splendid lesson of analogy. He emphasized for us the idea that the influence of each life may reach out undreamed distances through space and time to make the forlorn and shipwrecked take heart again.

Pointing in the same direction, but of infinitely deeper meaning than the lines of the poet, is the reality of the story, the sermon, the poem which the geologist sees, and which must of necessity reach its recognition through his eyes and its expression through his voice. The footprints and the stages of the path on which they appear are to us not merely evidences of an unending influence; they are tangible proofs of progress from eon to eon which might well help a forlorn

world to take heart once more. We may not understand the method by which betterment has come, but we see the stages of its movement and realize that, whatever struggles the future may have in store, we shall always be credited with a margin of safety when we risk ourselves in the cause which makes for uplift in the truest sense.

Without assuming more than is involved in the field of his daily work, the geologist stands before the world as the interpreter of one view of great truths fundamental to human interest and belief. It was in large measure this depth of vision that stimulated Darwin to his epoch-making work, giving to biology and to the whole range of human thought his progressive evolution. The story of the Earth stands as the background out of which history emerges and against which its movement must always be projected. The world needs now, as never before, a broad and deep view of all that may concern humankind of the present and future. The student of earth sciences was once a contributor to the wider philosophy of nature and its relation to man. It may be his duty now to make sure, not only that his influence is felt in advancement of material welfare, but that he serve also to point out the lesson of the foundations of the earth and to show that strength may still come from the hills.

# RE-SHAPING OUR FOREST POLICY

By Professor J. W. TOUMEY

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WHAT is wrong with American forestry? For twenty years magazine articles and public print in general were loud in praise of what appeared to the layman to be rapid progress in forestry. To-day these same periodicals are seriously questioning the security of our future timber supply. Our metropolitan press and country newspapers are calling attention to the growing scarcity of forest products, particularly high grades of lumber and wood pulp. Sunday editions of our more important papers are printing articles dealing with the scarcity of wood and the remarkable advance in price and urging the necessity for forest conservation. As a nation we have been prone to look with satisfaction upon the development of the U. S. Forest Service from the small beginnings of three decades ago to a great department of the national government, reaching into every corner of the country and disposing of an annual budget of more than six million dollars. We have pointed with pride to our hundred fifty million acres of national forests all established within the past thirty years and now under management for sustained yield. We have created departments of forestry in many states and acquired several millions of acres of state forests. We have established more than twenty schools of forestry and departments of forestry in our colleges and universities. At present thousands of foresters are coming in contact with our forests where there were none thirty years ago. Forestry is no longer an unknown profession. We have a rapidly increasing forestry literature. The past three decades have seen much water pass under the bridge, yet with all this the problem of our future timber supply remains unsolved. There appears to be no hope for its solution under our present forest policy.

Lumbermen who have been exploiting our forests and transforming them into vast areas of desolation see the end of their supply of raw materials. Some of them have publicly announced that both national and industrial welfare demand the early development of an American forest policy which will substitute for indifference, ignorance and accident, an intelligent, practical, equable and concerted program for the replacement of forests adequate in area and quality for the future needs of the nation. National, regional and local associations of lumbermen

and large users of forest products such as the National Lumber Manufacturers' Association, Western Forestry and Conservation Association, the Southern Pine Association and the American Paper and Pulp Association, have recently established forestry committees because they see the imperative need of forest renewal if the industries which they represent are to endure. National and regional associations of professional foresters, such as the Society of American Foresters, and the United States Forest Service, are diligently at work in an effort to create a public sentiment which will force the solution of the problem of forest renewal. Vituperation and condemnation of the lumbermen and private owners will not solve the problem. It can only be solved through change in point of view, through the adoption of a new policy effectively carried out. We must learn to treat the forest as a renewable resource. In my judgment, this can only be attained through the heartiest co-operation between the public and the owners of our forests.

Although the lumberman and layman appreciate the seriousness of present conditions, if these are permitted to endure, they are discouragingly indifferent when it comes to the point of providing an effective remedy. Although they know that the forest influences the life and property of towns and cities, states and nations, each individually "leaves it to George" to change present conditions. Although they know that there is essential need for forests under sustained yield to supply necessary raw materials, to protect water-sheds and regulate the flow of streams, to afford refuge for wild life, to maintain soil fertility and provide recreation grounds for the public; under our present forest policy and forest laws this recognition is not checking forest devastation and there is no hope that it will.

The public have been sitting on the side lines and silently witnessing the disappearance of one of our greatest resources. This is all the more deplorable from the fact that the forest is a renewable resource when given conscious care. Although the lumberman and the private forest owner see the end of the supply of virgin timber the remainder is harvested for the most part with scarcely a thought and entirely without consideration for future crops. The regrettable fact is that while they appreciate the deplorable situation into which we are rapidly drifting, they are not interested in doing very much in the way of forest replacement. It is rare indeed that any provision has been made in the past by private owners for starting new crops, and little effort has been expended in protecting the second growth which follows exploitation. What protection the private owner has given his forest property has centered in protecting his mature timber. He has spent little to keep forest lands in continuous production. New crops have been usually left to chance. In short the private owner of forest property in this country has not been and is not now in the business of growing timber

although he often owns vast areas of absolute forest land which ought to be maintained in continuous production.

### Evolution of Our Lumber Industry

For a hundred years American lumbermen have been acquiring and bringing together operating units of timberland to be exploited and finally left to become areas of desolation and waste without hope of future crops of essential value. They have accumulated acreage in one locality, devastated it, moved to another and repeated the operation. The process of moving into a virgin forest, destroying it from the standpoint of sustained yield and moving into another has gone on since the settlement of our country. With the reduction in the supply of pine and spruce stumpage in New England, American lumbermen moved into the great unbroken forests of the Lake States. After a few decades they left this region a desert of blackened stumps without reproduction and moved into the southern pineries where vast areas of virgin soft woods awaited them and to-day they are trekking across the plains to our last great bulwark of virgin timber, the Pacific Northwest.

Early in the last century New England supplied the bulk of the forest products consumed by the entire country. To-day her timber needs are largely supplied from outside sources. Thirty to forty years ago the Lake States formed the greatest lumber producing region in the world. To-day they scarcely supply their own needs. A decade ago the South was at the crest of its timber production. The apex has already been reached and the decline in annual yield is well under way. Although this region has been for two decades the greatest producer of high grade timbers of any region in the world it will soon pass as an exporting region and be scarcely able to supply its own needs. Investigations made by the United States Forest Service show that in another ten years more than one half of the localities in the South from which the mills now obtain their logs will be cut out and more than three thousand saw mills operating in pine will be forced into idleness due to exhausted stumpage. It should be emphasized that the present yield cannot be maintained because the stumpage is no longer there. In the place of vast areas of southern pine which for the past quarter century have been the world's chief supply of high grade timber there will be left many million acres of denuded and devastated forest largely without reproduction and an economic waste.

The progressive exhaustion of the forest capital of New England, the Lake States, and the Southern States, particularly the laying waste of a large part of the absolute forest land east of the Great Plains, is now forcing America to draw more and more of her forest products from Canada and the Pacific Coast. In another decade the Pacific

Northwest bids fair to supply the bulk of the nation's high grade timber.

### Enhanced Cost of Forest Products

The consuming public do not as yet fully appreciate what this means in enhanced cost of forest products. Lumber is an unwieldly and bulky product. A large part of its cost to the consumer is freight. Even now we pay about one hundred and seventy-five million dollars annually for railroad transportation of forest products. When the bulk of our timber comes from the Pacific Coast our annual freight bill on forest products alone is likely to exceed a half billion dollars. Were the supply of timber on the Pacific Coast unlimited in quantity and in no danger of exhaustion it would still be economically unwise to continue the devastation of absolute forest lands east of the Great Plains and make no attempt to reforest lands now idle. In the long run national economy demands that our forests be well distributed over the country.

The falling off in supplies of stumpage in eastern United States, thus causing the people to depend more and more on the Pacific Coast and importations from Canada, has had an important effect upon values. Furthermore the segregation of the national forests which embrace about one fifth of the total forests of the country from the public domain has left the lumbermen no new fields to conquer, no new sources of supply coming as free gifts from the nation. As the lumbermen cut out their present holdings they will find it increasingly difficult to find new fields for their activities. As a consequence we are at the beginning of keen competition by saw mill operators for our remaining stumpage. Heretofore the price of stumpage has been low. From now on it will increase with more or less rapidity until it approaches the actual cost involved in growing a crop of timber. Stumpage prices are certain to maintain a steady increase even through periods of rise and fall in the lumber market. The peak will not be reached until it sells at or somewhat above the actual cost of its replacement. Measured by this standard, although all classes of stumpage are rising in value, it has not as yet reached a price anything like the actual cost involved in establishing and developing commercial stands under forest management. Stumpage is at the beginning of a steady and rapid increase in price and is destined within the next decade or two *to reach two to four times its present value.*

The increase in lumber prices during the war and since the armistice has not as yet been reflected in the cost of stumpage. Those of us who are consumers of wood are looking for the prices of saw mill products to fall. Although there may be some fluctuations in present wholesale and retail prices, the general trend will not be downward, for

the excessive profits now being made by the lumber manufacturers will shortly be transferred to the rapidly increasing price of stumpage. There will be no such thing as a return to pre-war values and we are never again likely to see lumber sell at prices prevailing six to ten years ago.

A few months ago quarter-sawed white oak suitable for furniture sold for four hundred and forty dollars per thousand feet, b. m. in New York City, oak flooring sold for three hundred and forty dollars per thousand feet, b. m., in the Boston market. Second growth white pine box boards have recently sold in New England for sixty dollars per thousand feet, b. m., and chestnut plank from local mills has recently brought as much as seventy dollars per thousand feet, b. m., in Connecticut. Only recently certain grades of Douglas fir in the State of Washington have brought for the first time in history as much as one hundred dollars per thousand feet, b. m. These values are fully three times pre-war prices for the same classes of material.

### The Paper Situation

So far as available wood for paper is concerned it is conceded by experts that the visible supply of pulp wood in eastern United States will carry our mills but few years at the most. With the enormous increase in demand for paper in recent years, the mills of New England and New York have been utterly unable to increase their supply of raw products except through importation from Canada. Secretary Houston has recently stated that only one third of the American newspapers issued in 1919 were printed upon the products of our own forests. Although twenty years ago practically all our paper came from our own woods to-day much of it is from Canadian forests. We are even importing news stock from Norway and Sweden.

This is a paper age. The American Paper and Pulp Association states that since 1880 we have increased our annual consumption of news stock alone from three pounds per capita to nearly thirty-five. Our total consumption of all classes of paper is well over one hundred pounds per capita. So far as stumpage for paper is concerned we are already in a serious and critical position. During recent months some of the manufacturers of paper pulp in New York and New England are reported to have paid as high as thirty-nine dollars per cord for spruce.

Only a few months ago the Secretary of Agriculture in calling attention to the large areas of pulp wood along the Alaskan Coast stated that here is a supply to which the nation can turn for immediate relief while it is developing new supplies through forest replacement. *Are we as a nation going to develop new supplies through forest replacement?* We are not unless we re-shape our forest policy.

### The Cause of Increased Prices

The recent increase in cost of all classes of forest products can not be entirely credited to the war. The cost of forest products to the consumer has increased more than any other important class of basic resources. Although post-war conditions are to blame for the sudden jump in prices within the past year, a part of the increase must be credited to the rapidly increasing scarcity of commercial timber which had begun to be felt even before the war.

Heretofore only a small number of American citizens whose voices have been like a cry in the wilderness have taken more than a passing interest in our forests and the problems relating to their use and renewal. The average man has been satisfied so long as the market supplied him with forest products at low cost and he was able to find wild places for hunting, fishing and other forms of recreation. The recent public interest in forest renewal is due to what you and I, the average citizen, are forced to pay for wood. When we pay three or four times the former price for a standard product we stop and reflect. Although in this case we appreciate the part that the war has played in increasing the prices we find that back of the war, back of the manufacturers, back of the wholesaler and retailer is the basic problem of raw materials.

### The Magnitude of Our Forest Industry

The magnitude of our forest industry and the volume of forest products that enter into our domestic and export trade is shown in our latest census report. In round numbers fifty-two thousand manufacturing establishments in this country, or nineteen per cent of all, are dependent for their continued operation either wholly or partly upon the output of raw products from the forest. These establishments furnish employment for 1,130,000 workers or approximately one-sixth of the seven million workers in manufacturing industries. Our forests supply the raw materials for industries in which a total of three billion dollars is invested. Yet we are without an effective forest policy, without laws or machinery under which adequate forest replacement is possible.

### False Basis of Our Lumber Industry

Our lumbering and allied industries have been erected on the basis of the original or virgin forest. Even the average man now sees that we cannot go on indefinitely relying upon the old-growth forests. We have already reached the point where we clearly see the commercial exhaustion of old-growth timber. It has already completely disappeared from many states and in other states only a remnant remains of the vast stands that less than fifty years ago were the most

important sources of the world's timber supply. Ultimately all our timber must come from second growth forests. Our attention, therefore, must immediately be directed to the areas from which the old-growth has been removed. It is these areas that must furnish the bulk of our timber supply before the end of the present century. While we are improving and protecting the young growth on these areas and planting new forests, there should be a closer and better utilization, a better protection and more careful husbanding of the remaining old growth in order that it may last until a new growth sufficient to supply a considerable part of our needs is ready for the saw and axe.

Only a few months ago one of our largest private corporations owning timberland in the United States published a prospectus distributed for the purpose of advertising a bond issue in which it was stated that at its present rate of annual cut, its stumpage will last about forty years. Like practically all other private owners of timberland this company considers its stumpage in the same light as the miner considers the mineral in his mining claims. In other words the company considers it exhaustible and pays no heed whatever to the possibility of its renewal. This case illustrates the almost universal attitude that has prevailed heretofore in the management of American timberland by private owners. So long as private citizens control through ownership nearly four-fifths of our forests and so long as the public by co-operation or other means are unable to stop forest devastation on private holdings there will be insufficient reproduction and present prices for forest products are only a fraction of what they are likely to be later.

## Our Lavish Use of Forest Products

As a nation we have grown to our present stature lavish in the use of wood and other forest products. Heretofore we have looked for and found our needed supplies in the vast areas of virgin forest which covered nearly fifty per cent of this country when settlement began. We have been favored with relatively inexpensive forest products. We have lavishly used a hundred species of trees, many growing to massive size and splendid proportions. We have had abundance of wood for every need and have become accustomed to using it without stint and without thought for the future. We have led the world in the consumption of forest products and we have gathered them from the abundance provided by nature. So long as unoccupied public domain could be deeded in the form of homesteads and timber claims to the individual and at a cost to them of but a few dollars per acre, stumpage necessarily remained low. There was always a large supply in private hands awaiting a market. The

nation in her generosity gave her splendid areas of virgin forests to her citizens. The private owner could well afford to sell timber on the stump for a few cents per thousand feet, b. m. Less than a half century ago virgin redwood stands cutting from fifty to one hundred thousand feet, b. m., per acre, were given away or disposed of by the nation for two and one half dollars per acre on a basis of two and one-half to five cents per thousand feet, b. m. A few months ago British Columbia, which had the foresight to reserve its timber, sold less valuable stumpage for as much as $250.00 per acre.

## Forest Reserves

The disposing of absolute forest land for a mere fraction of its real value continued until the Cleveland administration. We never should have permitted any of it to pass to private ownership. Canada did not and to-day is reaping the benefit. Having made this serious economic mistake which has led to extravagance, waste and lavish use, we should have corrected it by creating national forests long before we did. As it is, *our publicly owned forests are entirely inadequate to supply more than a mere fraction of our future requirements.* Unless the area is greatly increased, which can only be done at large expense, what the forester has done in the past and what he will be able to do in the future in their organization and management can have but little effect in solving our forest problem.

It was to the everlasting good fortune of the American people that a rider on an appropriation bill in the early 90's escaped the eyes of Congress and gave authority to the president to create national forests from the unoccupied public domain. It is difficult to say when or how the wholesale misuse of the public land laws would have ended if it had not been for the authority under which about one hundred fifty national forests with an average area of nearly one million acres each have been segregated from the national domain and dedicated to the production of timber under regulation and ownership by the nation.

It is fairly safe to say that if the former policy of the land office had continued until the present day all our forests would ere this be privately owned and our outlook for timber supplies adequate for future needs would be far more discouraging than it is.

## Time for the Nation to Act

It is time for the forester, the conservationist, the lumberman, the wholesaler, the retailer and the consuming public to sit down together to consider our forest capital, to work out a form of action, a policy having for its object a form of utilization which will stop further devastation and insure forest renewal. It is some encouragement to know that the lumberman appreciates the necessity of stopping further devastation and beginning the reforestation of the vast areas of idle

land which have resulted from past practices. It is unfortunate that although he appreciates the situation he is not as yet willing to undertake forest renewal on his own lands due to his fear of financial loss. It is believed that the more far-sighted, however, are willing to undertake forest renewal if they can secure adequate assistance and financial aid from the public. The public at this time can ill afford to force restrictions and regulations which the private owner can only carry out at large financial loss. The public who are large beneficiaries from forest replacement must bear a part of the burden. With co-operation and generous support on the part of the nation and state in the securing of forest replacement on private forest lands there must be state laws which make it obligatory.

The solution of the very vital and pressing problem of future timber supplies lies first in increasing our public forests,—national, state and communal; secondly in the organization of privately owned forests for sustained yield. We should clearly appreciate, however, that no improvement over our present deplorable situation is possible without liberal financial support on the part of the public. The cost of a single battleship will cover the great burns of the Adirondacks with productive forests; the cost of a single battleship will clothe a million acres of Pennsylvania's areas of desolation and waste with splendid coniferous forest; the cost of a single battleship will develop a forest fire service which in co-operation with the states should effectively protect half the nation's forests.

### The Shaping of a Forest Policy

To a measure nations go through much the same processes of evolution in respect to forest renewal. We can look with profit to the experience of the older nations in our effort to attain forest renewal in this country. Practically all forests both public and private in Germany, France and Sweden are organized for sustained yield and the annual cut bears a close relation to the annual growth. In these countries the forest problems of the past century have centered in attaining reproduction of desirable species in fully stocked stands. In order to show what is meant by the reproduction of desirable species in fully stocked stands, let me cite the case of Connecticut. Forty-six per cent of this state is returned as timberland, yet when one goes to our retail and wholesale lumber yards he finds that less than ten per cent of the timber offered for sale comes from Connecticut forests.

For a hundred years France has had a fixed policy with adequate reproduction as its chief aim. Without virgin forests she was able to supply the essential needs of the allies for wood during four years of destructive warfare and without seriously encroaching upon her forest capital. China may be cited as the antithesis of France. She

has never practiced forest renewal. Virgin forests disappeared ages ago and with them a great basic resource, the loss of which she most keenly feels to the present day.

The history of the ages demonstrates that in every nation forests decrease in area and in quality and in time disappear when under unregulated private control. History also demonstrates that forests are adequately maintained wherever forest renewal is accepted by the people as a public responsibility and laws are enacted under which it is attainable without serious loss to the individual.

With our relatively small area of publicly owned forests it is shortsighted and most unwise to continue longer our past policy of unrestricted practices of exploitation and devastation of private forest property. The time is at hand when this nation must either initiate a policy of land purchase which will bring under public ownership and control an additional one hundred twenty-five million acres of absolute forest land or else the private owners of the productive forests of America must shift their point of view. They must give up exploitation and devastation because it injures the public. It is not believed the public can secure through purchase, at least in the immediate future, sufficient acreage of absolute forest land to meet our essential requirements. *It is for this reason that we now witness a nation-wide agitation for a national forest policy having for its primary object forest replacement on lands privately owned.*

This agitation was begun by Colonel H. S. Graves, formerly Chief of the U. S. Forest Service, and is being continued in that service by Colonel Greeley, his successor. It has been taken up by the Society of American Foresters, and a few months ago a committee of that society submitted a comprehensive report to its members which has since been accepted by majority vote of the society. Within the past few months more or less complete plans for national and state forest policies have been formulated and advocated by many organizations of foresters, lumbermen and large users of forest products.

The leading forest policy proposals now before the country are three:

(a) The program of the Committee of the Society of American Foresters.

(b) The program of the American Paper and Pulp Association and various lumber interests.

(c) The program advanced by Colonel H. S. Graves.

These proposals have been for the past nine months under discussion in technical magazines, lumber journals and in the public press. All have been criticized more or less severely and each has its advocates. All recognize the necessity for forest renewal. They do not differ in results desired but rather in methods and processes by which results are to be obtained.

The program of the committee of the Society of American Foresters insists that laws should be enacted by the national Congress under which severe penalties are imposed upon the private owners of absolute forest land who do not organize their property and practice forest renewal. *It places the responsibility for sustained yield chiefly upon the private owner of forest property.* This program is more centralized than the others, more sweeping in character and places greater emphasis upon the requirements. This program is radical in that it is centralized in the federal government and combined with a plan for the industrial control of the lumber industry.

The program of the American Paper and Pulp Association insists that the national government should act through the states and that through co-operation and financial support the nation and the state make sustained yield on privately owned forest property attainable without financial loss to the owner. *It places the responsibility for sustained yield chiefly on the public whom they consider the chief beneficiary.* This program does not recognize the mutual responsibility of the private owner and the public and is antagonistic to mandatory state laws for the renewal of forests on absolute forest land that is privately owned.

The program advanced by Graves sets forth a plan under which the national government working through the states provides technical assistance and financial support in effecting forest renewal on private property but at the same time *insists that the state exercise mandatory regulations and provide adequate assistance in co-operation with the national government to make forest renewal certain. It places the responsibility for forest renewal on both the public and the private owner.* Co-operation is the key to this plan. It is to be noted, however, that the idea of mandatory laws to control forest replacement on private lands is basic as it is in the more radical program.

### The Program of the Committee of the Society of American Foresters

The committee of the Society of American Foresters has published and widely distributed a most detailed and comprehensive plan. This plan sets forth nine fundamental principles as follows:

1st: Prosperity in peace and safety in war require a generous and unfailing supply of forest products.

2nd: The national timber supply must be made secure.

3rd: The transformation of productive forests into idle wastes impoverishes the nation, damages the individual, is wholly needless and must be stopped.

4th: Unless and until lands can be more profitably employed for other purposes they should be used to produce forest crops.

5th: The ownership of forest land carries with it a special obligation not to injure the public.

6th: The secure and steady operation of the lumber industry is of vital concern to the public.

7th: The lumber industry being nation-wide, uniform and adequate control over it must be national.

8th: National legislation to prevent forest devastation should have three objects:

(a) Control over private forest land.

(b) Only such control as may be necessary to place forest industries on a stable basis.

(c) The transfer of control back to the forest industries as soon as they are willing and able to assume responsibility and respect the public interests.

9th: The national, state and community forests should be maintained and largely increased.

The legislation suggested in furtherance of the proposed plan calls for a national committee in Washington consisting of the Secretary of Agriculture, the Secretary of Labor and the Chairman of the Federal Trade Commission with supreme authority over private timberland, and to operate through regional organizations of government foresters assisted by representatives of the Federal Trade Commission and the Department of Labor.

This commission is political and certain to change with each administration. The legislation proposed goes far beyond that dealing with forest renewal. It provides for reports on the production of forest products from private timberland, reports on sales, stocks on hand, costs and other matters not generally available to the public. It even fixes accounting methods and provides for the control of production when judged desirable by the commission. It permits the government to cut its own timber and provides for the creation of labor councils of employers and workers to consider wages, hours and various other matters. It excludes farmers' wood lots from the legislation proposed and provides penalties for the enforcement of the law. The plan has been severely attacked by the lumbermen of the country and by many foresters as well.

The Program of the American Paper and Pulp Association

The adherents of this program although fully recognizing that our forest capital is being exhausted much faster than it is being replaced are unwilling that the private owner should assume responsibility for forest renewal. This group has also published and widely distributed a detailed plan for sustained yield. This plan sets forth the following principles:

1st: A program providing for a permanent timber supply must be adequate and practical to produce the needed results, just to all interests concerned and acceptable to the majority.

2nd: There is urgent need for co-operation by the national and state governments to accomplish:

(a) A forest survey and land classification.

(b) A great extension of public ownership through the purchase of cutover lands.

(c) An extension of Federal co-operation with the states in fire protection and in measures which will reduce the fire hazard and afford better opportunities for natural regeneration.

(d) Better forest taxation laws, the establishment of state nurseries and the preparation of working plans for the purpose of encouraging the private owner who wishes to grow timber. A provision that if the private owner of land only useful for growing timber refuses to co-operate, his land be acquired by the public at a fair valuation and made a part of the area of public forests.

(e) A large program of planting on lands which have been so far denuded that there is no hope of securing an acceptable crop through natural regeneration.

Special emphasis is placed in this program upon uniting professional foresters, timberland owners and consumers of forest products upon an immediate plan of greatly increased fire protection and a more general acquisition by the public of cutover lands.

In order to make the proposed plan operative the following national and state legislation has been proposed:

### National Legislation

(a) A present annual Federal appropriation of one million dollars to be expended in co-operation with the states for fire protection, care and management, and the distribution of planting material, this sum to be gradually increased to a maximum of five million dollârs.

(b) An annual appropriation of five hundred thousand dollars to continue as long as necessary and to be expended in co-operation with the states in making a complete and accurate forest survey and classification of both public and private forests.

(c) A permanent annual Federal appropriation of not less than three million dollars to be expended in extending the area of national forests until their total area reaches a minimum of at least two hundred million acres.

(d) The extension of the general authority of the Secretary of Agriculture to exchange national forest land, stumpage and timber certificates for private timberland within or adjacent to existing national forests.

(e) A present annual appropriation of at least two million dollars for planting operations on the national forests.

(f) A present annual appropriation of five hundred thousand dollars for forest investigation and research.

(g) The extension of the Federal Farm Loan Act to include loans on private forest property and to be expended in the improvement of such lands and in employing measures to promote timber growth.

The appropriations herein requested are modest when compared with the magnitude of the forest industry. There is no doubt that were such appropriations available they would materially improve conditions but in the writer's opinion they cannot in themselves solve the problem of sustained yield on privately owned timberland.

### State Legislation

The state legislation proposed in this program is based upon the following principle: If forest land like agricultural land bear its share of the support of the state it is essential that it be organized and developed for sustained yield. It is recommended, therefore, that bills be introduced into the state legislatures embodying principles in harmony with the suggested Federal legislation but applicable to the special needs of each state. These bills should provide for a forest survey of the state in co-operation with the national government; for their organization for state-wide fire protection; for adjustment of taxes; for assistance in the practice of forestry by private forest owners, by supplying planting material, making working plans and supervising silvicultural operations free of charge or at the lowest possible cost. These bills should also provide that private forest land may be taken by the state at a fair valuation and made a part of the public forests of the state only in case the private owner refuses to avail himself of the co-operation and assistance provided by the public. Also that a adequate support be given by the state for educational and experimental work in forestry. Furthermore these bills should provide for adequate state appropriations to make them effective.

It is to be noted that the advocates of this plan are willing to accept generous appropriations from national and state governments for the furtherance of sustained yield on private timberland. They are unwilling to assume a part of the responsibility for attaining sustained yield. The state legislation proposed is weak in that it does not adequately recognize the responsibility of the private owner. It is recognized, however, that the private owner has a moral and legal obligation to handle his property in such a way that it does not become a public nuisance and that the state may require him to conduct his cutting operations in a manner to lessen the fire danger.

### The Graves Plan

The immediate program also opposes complete public control of private timberland by a national commission. The advocates of this

plan believe whatever control is exercised by the nation must be by the Federal government acting with and through the several states. *They recognize a decided responsibility on the part of the private owner of timberland.*

This program has been fully described by Colonel H. S. Graves (a) in a pamphlet issued from the office of the Secretary of Agriculture under the title, "A Policy of Forestry for the Nation," (b) in a mimeographed report from the U. S. Forest Service under the title "The principles of a program for Private Forestry" and (c) in a mimeographed report by the U. S. Forest Service under the title "The next steps in a National Forest Policy."

Due to the emphasis placed upon co-operation and from the fact that the program involves local plans to fit local conditions it cannot be as specifically outlined as the foregoing plans discussed. It can, however, be best outlined under the two heads (a) Principles involved, and (b) Federal and state action required.

### I. Principles Involved

1st. The need of a Forestry program in which it is recognized that no single legislative measure can accomplish the objects desired but that a central national policy is needed adaptable to special regional conditions.

2nd. The object of the program should be to bring about permanent forest production on all lands which are best suited for the growing of timber, and the recognition that this can be done only by adequate protection and by the replacement of old timber when cut with new growth.

3rd. Public forests should comprise critical areas on important watersheds and extensive areas elsewhere to serve for the production of forest products, as demonstration forests and as centers of co-operation with private owners.

4th. The problems of farm forestry should be worked out through the medium provided by the public to educate farmers in better methods of agriculture, and the utilization of commercial timber tracts should require that the public take steps to stop destructive processes and substitute constructive methods of forestry.

5th. That private ownership of forests carries with it certain definite responsibilities, in that private ownership does not give the right to handle forest lands in a way that jeopardizes the public interests.

6th. The character of the forestry problem is such that as a rule the private timberland owner seldom adopts measures tending to the perpetuation of forests upon his own initiative and without direction and co-operation by the public.

7th. The safe-guarding of the public interests in forests requires laws to the effect that the private owner adopt measures for forest replacement but at the same time be given such public assistance and co-operation as may be needed to make such measures feasible in practice; that the mandatory principles in these laws aim to establish uniform requirements to apply to all timberland alike and to be within the possibilities of practical application.

## II. Federal and State Legislation Required

### A. Federal Legislation

1st. For the extension of national forests.

(a) Authority to exchange national forest land, stumpage and timber certificates for private forests within or adjacent to existing national forests.

(b) Continued appropriations on a generous scale for acquiring forest land by purchase, until ultimately such acquisitions extend into all the principal forest regions in the United States.

2nd. For co-operation with the states in forest protection and silviculture.

(a) Authority to provide the states liberal financial help and technical aid.

(b) Authority to greatly expand the activities of the U. S. Forest Service in co-operation with the states as now authorized by Section 2 of the Weeks law; this authority to carry with it a yearly appropriation by the National Government of not less than $1,000,000 to assist the states in forest protection and silviculture, but the expenditures in any state not to exceed the expenditures of the state for the same purposes, and the benefits of the law limited to the states which establish mandatory laws fixing minimum requirements.

3rd. For the securing of better forest taxation and insurance laws, including legislation carrying a moderate appropriation to devise model forest taxation and insurance laws.

4th. For loans on growing timber, through the extension of the federal law concerning farm loans, but such loans to be issued upon a specific obligation assumed by the owner to retain the land in growing timber and to protect and care for it during the life of the loan.

5th. For land classification, through the states but with federal assistance, in order that all lands be put to the most advantageous use and ill-advised attempts to cultivate land which is not agricultural in character be stopped.

6th. For forest surveys and research including a special appropriation for a comprehensive survey of the forest resources of the

United States in co-operation with the states and private interests, and for aid to enlarge research in forestry and in forest products along the lines already under way by the U. S. Forest Service.

B. State Legislation

Although this program recognizes that the differences in forest conditions in the several states do not make uniform state forestry laws possible, it recognizes that certain main principles are applicable to practically all of the states which contain forest land but variations in methods of enforcing them are necessary.

The state legislation necessary to carry out the foregoing national program is as follows:

1st. The enactment of laws to the effect that the private owners of forest land are legally responsible for preventing their property from being devastated or denuded of forest growth, and that it should be incumbent on the State Forestry Board to enforce this principle.

2nd. That state law in pursuance of the above should make the following measures obligatory, leaving detailed methods of enforcement to the State Forestry Board.

(a) Organized protection of all forest lands in the state under a system by which the cost is met by the Federal Government, the state and the private owner.

(b) Police regulations for the control of forest fires during critical periods.

(c) Effective disposal of slash in all cutting operations under a method best suited for the particular forest type.

(d) Cutting methods determined and established by the State Forestry Board for application in forest types where protection alone is insufficient for forest renewal.

(e) To provide for assistance to forest owners through the State Forestry Board in the study and classification of land, and for co-operation with the Federal Government in this classification.

3rd. To provide for assistance to the private owners of forest property in attaining forest renewal and to provide for forest investigation and for the systematic planting of denuded lands in state ownership.

4th. To provide funds and the machinery for a large extension of state and communal forests.

5th. To provide a non-partisan control of forestry work in the state through a Forestry Board representing the forest-using, agricultural, and educational interests in the state, with the executive forest officer a technically trained man known as the state forester.

6th. To provide better taxation laws through the creation of a commission in each state to study existing practices and their effect on

forest replacement and to recommend to the state legislature a revision of present laws where advisable, the commission to receive co-operation and aid from the Federal Government.

The differences in the foregoing plans can be briefly stated as follows:

*The more radical plan* proposes national mandatory laws governing privately owned forest lands. Chief emphasis is placed upon specific requirements imposed upon the owners although public assistance is provided in certain matters. *The more reactionary plan* proposes no mandatory laws, makes no requirements whatever but relies upon encouragement and inducements in the way of public co-operation and aid, with the public ownership of forests as an alternative. *The intermediate plan* imposes certain requirements but emphasizes co-operation and public aid. It makes public action an integral part of the plan and recognizes the necessity of the public's sharing the cost and responsibility. The advocates of this plan believe that state legislatures must provide certain mandatory requirements for forest renewal but that both Federal and state governments must provide co-operation and financial support in making effective a system of forest management for each locality which will result in sustained yield without placing an undue burden on the private owner.

It is the writer's judgment that the solution of our forestry problem will be found most likely in the development of a forest policy based upon the principles and legislation now under process of development by the advocates of the intermediate plan. This plan recognizes a dual responsibility resting upon both the public and the private owner of forest property. It recognizes not only the necessity for liberal national and state appropriations and the heartiest co-operation between the public and the private owner but it also recognizes that where there are reciprocal public concessions to be safeguarded reasonable requirements are essential.

Although we are not yet ready for radical Federal coercive laws and it is the writer's hope we never will be, the time will very likely come in the not distant future when the private owner, as in many European states, although permitted by the state to cut by whatever method he pleases, must attain adequate reproduction on cutover areas to satisfy the rigorous examination of a board of foresters. Some day the state will say to the private owner, "We are concerned in keeping absolute forest land permanently under forest. We judge you by the condition of your cutover land. If it is unsatisfactory from the standpoint of public welfare, we will improve it if you do not, and charge the cost against the property."

# CONTROLLING THE AIRPLANE AT TWENTY THOUSAND FEET

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HOW the airplane will sail at twenty thousand feet can be predicted with confidence. How the pilot will sail his ship at that altitude is quite another question. Each year has witnessed improved designs in ships, so that planes to-day climb easily to twenty-five thousand feet; whereas five years ago they rarely exceeded ten thousand feet. During the war the aviator was called upon to drive close enough to the trenches to use his machine gun and to rise to eighteen or twenty thousand feet for combat purposes. Machines assisting the artillery in range finding did not often work above eight thousand feet. The different types of work called for different types of machines. Perhaps we should say for different types of pilots as well. As some machines can not rise to great heights, so too some pilots are incapable of work at great altitudes. General Squier reports that 61 per cent of men examined for altitude work are capable of flying to twenty thousand feet or more; 25 per cent. should not fly above fifteen thousand feet; and 14 per cent. were inefficient above eight thousand feet.[1]

High altitudes impose new conditions upon both the man and the machine. Rohlfs, the holder of the American altitude record, tells us that on a summer's day, when people are sweltering in the heat, he experiences in his climbs a temperature of twenty-five degrees below zero, and a wind of from one to two hundred miles an hour. Of course, the air pressure is greatly diminished. Both pilot and airplane have to contend with greatly decreased temperature and air pressure as they rise. This necessitates certain changes in the machine and certain changes in the man. The carburetor and the water system both have to be adjusted to meet the new requirements. The heart rate, the respiration rate, the blood pressure have to be adjusted to keep the pilot's system working. As the pilot and the plane are a unit in the work they do it is of course as important that the machinery in one should be studied, understood and cared for as thoroughly as in the other.

A great deal of work has been done to select and classify the fliers. Each of the countries in the war had an Air Medical Service

[1]Aeronautics in the United States, 1918. George O. Squier, Proceedings of the American Institute of Electrical Engineers. Vol. 38, No. 2, p. 81.

as a part of their air forces. At Mineola, Long Island, many tests and experiments were made in the Medical Research Laboratory and their results published by the War Department, Air Service Division of Military Aeronautics. Much more, of course, must be done and will be done.

The effect of the lowered temperature upon the aviator has not been thoroughly studied. We do not know just to what extent his senses and his reaction are affected. Certainly there must be some modification of his abilities by the change. The reduction in atmospheric pressure has its greatest effect in the depletion of oxygen supply. The merely mechanical effect of reduced pressure does not seem to affect vital functions. It does, however, cause great discomfort. We must remember the fact that we live at sea level, in an atmospheric pressure of about fifteen pounds to the square inch, and that as we rise this pressure decreases. When we bring this to mind we recognize that nature has provided us with constitutions to resist this pressure. The balance between the pressure of our constitutions and that of the atmosphere is equalized. When we rise to eighteen thousand feet there is just about half the atmospheric pressure to be resisted. The most conspicuous effect is upon the eardrums. Just back of these delicate membranes is the eustachian tube running to the throat, and filled with air. Each time we swallow we open the tube which equalizes the pressure upon the eardrums. As we rise and the pressure in the tube becomes greater than that outside, one experiences a distinct pain which is relieved by swallowing. As an aviator descends quickly he finds it necessary to force the air into the tube against the drum by holding the nose and blowing gently: otherwise a quick descent would injure the drums. Next to the discomfort in the ear is the rather characteristic frontal headache. This is due to the change of air pressure in the sinuses.

The greatest discomfort and detriment are occasioned by the lowered oxygen tension. The pressure of oxygen on the membranes of the lungs is lessened and the blood receives a diminished supply of oxygen. This is all important. Oxygen is indispensable to the nerve tissues, to say nothing of all other tissues. The old saying, "No phosphorus no thought," is absolutely true if oxygen is substituted for the other element. In order to keep the tissues supplied with oxygen, when the supply is being diminished, nature resorts to some interesting expedients. The lungs seek a greater supply by deep respiration. The heart seeks to increase the supply by quickening the blood stream, the blood vessels co-operate, giving an increased blood pressure. The blood itself changes its constituency. The deepened breathing, the quickened heart, the heightened blood pressure are all brought about by stimulating brain centres which control these func-

tions. Should these centres not respond until the blood stimulating them is very depleted in oxygen the compensations would not occur promptly, and the aviator would collapse. For this reason these functions have been carefully studied.

Before the aviator collapses from any fault of his vital functions, he may become so inefficient in handling his controls that he wrecks his machine. In the so-called "rebreather tests" the psychologists would frequently remove the aviator because of incapacity to keep his attention on his work or to control his movements. This condition often occurred, as the man received less and less oxygen, before there was any threat of physical collapse.

Of course, any deterioration in the functions of the nervous system spells disaster to the flier. If we consider the central nervous system as artificially and roughly divided into three parts, one of these would be concerned with sense impressions which carry impulses to the brain and spinal cord, one would gather these impulses centrally, and a third would convey out-going motor impulses to muscles and glands. A study of the sensory nervous system with its end organs under varying conditions would be most valuable to the air man. For example, it seems that one's vision is somewhat better after ascending a few thousand feet. This seems to be due to the increased blood supply, especially in the choroid and retina of the eye.[2] But after rising to fifteen or twenty thousand feet the vision is distinctly impaired. Hearing under high altitude conditions does not *seem* to be impaired at all![3] It would be important to discover the effects of low oxygen supply upon tactual and kinesthenic senses as well as upon the somatic senses, as these play a part in getting the "feel of the ship."

The motor mechanisms are certainly greatly affected by altitude conditions. The loss of oxygen gives the muscles much the same effect as fatigue. I have noticed in the low air pressure chamber that the slightest expenditure of energy, such as gripping the stick hard, or pushing the rudder vigorously, or even moving around in my chair brought a quick, perceptible fatigue. Indeed, one may quickly exhaust his oxygen supply and become unconscious if he exerts himself at all vigorously, around twenty thousand feet. Not only do the muscles become easily fatigued, but muscular coordinations become very poor.[4] This is beautifully illustrated by experiments in handwriting. A few specimens of notes taken by a man in the low pressure chamber under conditions similar to altitudes of six, fourteen and twenty

[2]The *Journal* of the American Medical Association, Vol. 71, No. 17, p. 1394.
[3]The *Journal* of the Medical Association, Vol. 71, No. 17, p. 1398.
[4]Air Service Medical, p. 312 ff.

thousand feet are given on Figure 1. It will be seen that there is a progressive deterioration with decrease of air pressure. The lettering shows the effort required to control the pencil. The men could see the lines they made but found it most difficult to control the finger movements. I am inclined to think there are fluctuations in motor control so that for a moment or two the coordination is quite good and then becomes inaccurate again.

The French and Italian experimentalists early conceived the desirability of testing not simply sensory, or motor factors, but both of these and the central factors too. This they did by the well-known "reaction times" test, which consists in stimulating any sense, usually sight, hearing or touch, and recording the time it takes to make a movement in response to the stimulus; for example, if a light is flashed before the subject of the experiment and he moves his hand the instant he perceives the light, it requires about .19 of a second for the nerve impulse to reach the brain, to be directed to the motor nerves, to descend these nerves and contract the muscles of the hand.[5]

This is a very simple operation of the nervous system. It is almost as simple as a reflex action. It would seem that the most important factor, namely, the central processes, is not sufficiently prominent. A better type of test is one which obtains "discrimination time." In this test several different stimuli may be presented, the subject does not know which one is coming; also, he is required to make a certain type of movement for each type of stimulus. That means he must recognize the signal given and make the appropriate reaction. This involves much more brain activity. It is a far better test of mental alertness.

"A good pilot should feel entirely at ease in space. He should be able to recognize at once the slightest difficulties with his machine in any one of the three dimensions. He should possess fundamentally the skill of command to re-establish equilibrium at any instant, just as a cyclist on his bicycle, but with this difference, that there exists a slight space of time between the moment of the movement of control and that of the effect produced. It is necessary then to correct the movement made, and at that point is the delicate matter of making the movement with too much intensity, or, on the other hand, insufficient intensity.

"In a word, it is the instantaneous transformation of a passing sensation to precise muscular contractions, but of infinite variability, with the purpose of constantly reacting to the invisible movements of the atmosphere and with all the other difficulties which may occur. This capacity, as it seems to me, is, above all, the result of training. Repetition of the same movement results in the formation of a nervous center which commands all the muscles involved in the execution of these movements, and then of centers in the medulla, which become substituted for the brain, in a transformation of a sensation to a movement. This is the theory of reflexes.

"The formation of these reflexes varies with the temperament of each person. The rapidity of acquiring them constitutes what is called aptitude. But in so far as the pilot does not acquire this automatic feature of his

[5]Ladd and Woodworth, Elements of Physiological Psychology, p. 476.

not so much strain on my ears. this run.
so far 2,000 ft.

Series at 6,000 ft O.K little nervous at
first on account of noise but soon got
used to it.

Just feel a trifle bit dizzy at 14,000 other-
wise O.K. series went along O.K. and
my reactions seemed to be normal.

Feel dizzy otherwise O.K. reactions seem to
be coming OK feel OK otherise have
a feach of of of@ a headache.

Dizzy and groggy at 20000 ft
had trouble seeing rudder to
set it in neutral. somehow
everything seemed black

Sharp pain in front of head at
6000 ft

FIG. 1.

The third entry was written at 20,000 feet "altitude."

movements, he will have to furnish in his work a sustaining effort of attention, a great effort of will, which may go so far as producing nervous fatigue."[6]

[6] "Physiology, Physical Inaptitude, and Hygiene of the Aviator," by Dr. Guilbert, of the French Air Service. Air Service Medical, pp. 128-29.

To obtain an insight into the quickness with which a man recognizes a signal and makes the correct response, a form of discrimination time test was used in the Medical Research Laboratory at Mineola. In designing the test I sought to make the reacting movements similar to those of the pilot. An aviator's seat and controls, consisting of the stick and rudder bar, were placed in a large, low air-compression chamber, and electrical attachments were made to those controls in such a way that the time of discrimination was registered on a tape in units of 1/36 sec. Also, the direction of the movements of the stick and rudder bar were likewise registered. Through a window of the chamber a card was displayed which indicated how the stick and the rudder should be moved. When a shutter dropped, exposing the card, the timing device began to run and continued until the subject had reacted with both stick and rudder. The reactions, of course, tell us only how quickly the man made his discriminating responses. They do not tell us *how* he made them. He may have jerked his stick and his rudder with great vigor in such a way that if he had been in a plane instead of a steel chest he would have turned forty somersaults. As a matter of fact some of the men occasionally threw their controls with violence when under low air compression. This trait would disappear as the pressure returned to normal. It was not a constant performance. It, of course, is a result of the muscular incoordination mentioned above.

In determining the quickness of discriminating reactions under reduced oxygen conditions. I was fortunate to have for my subjects six experienced psychologists and one very intelligent enlisted man. Two of the subjects could not complete the series of tests. Four out of the other five continued the tests until their reactions had become quite automatic.

The procedure in the experiments consisted in placing the subject in the aviator's chair, explaining the reactions desired and in giving a number of trial reactions to accustom him to the apparatus and his duties. When he felt at home in the conditions imposed upon him, and had learned the best way in which he could make his responses, the actual testing began. Each subject was given a series of fifty tests at a time, never more than this. Occasionally a man would take but one series in a day; the work was dependent upon the availability of the men for the hours of experimentation. Each man was given his tests until his time of reaction, the mean variations of the time and the per cent of errors he made, all indicated that he had become as quick and accurate as it was possible for him to be. A learning curve was plotted for each man as he progressed. When it appeared that he had reached his highest efficiency, the tests in the low air pressure chamber were given. In most cases, however, the

"altitude tests" were given before the learning curve indicated a complete disappearance of improvement.

In the "altitude" tests the subject was first given a series of fifty at sea level, then he was allowed five minutes rest while the air pressure was reduced to an equivalent of six thousand feet altitude. At this point another series of fifty tests was given, followed by another rest of five minutes while the pressure was again reduced, this time to an equivalent of fourteen thousand feet, again a rest and a series at twenty thousand feet, another rest and a second series under the same condition, again a rest and a third series under these conditions. Then, after the usual five minutes rest the pressure was increased to an equivalent of fourteen thousand feet and another series of fifty tests taken, then back to six thousand and a final series at sea level. The nine series would average about eight minutes per series. The compression changes would be made at an equivalent of one thousand feet per minute. One or two physicians accompanied the subject in the chamber during the test. They were supplied with oxygen by means of rubber tubes connected with tanks outside of the chamber. Occasionally they allowed some of the oxygen to leak into the chamber. To allow for this specimens of the air were taken at the beginning of the first series at 20,000 ft. under the low compression and again after the completion of the third series at that stage.

It will be seen that the situation does not exactly duplicate that of the flier in the plane. There is the absence of the high wind, of the great cold, and, of course, the excitement incident to danger. But the most important condition which affects the aviator physically, namely the low supply of oxygen, is the same in both situations. The sort of signals to which the aviator responds when in a plane; slight movements of the ship; the sounds from the engine; signals from other ships when flying in formation; or the appearance of a hostile plane are all very different from the signal cards. But the time of reaction to the signal, no matter what the signal is, is a physiological matter. The time of nerve conduction from sense organs to brain and thence to muscles should remain the same. It would appear then that the effects of low oxygen upon discrimination time in the compression tank should also be descriptive of discrimination times in actual altitudes.

The first subject, A., who took the "altitude tests," did so after going through twenty-three series of fifty tests each at sea level. He did not however reach the equivalent of twenty thousand feet owing to a leak in the oxygen supply. The charts Figure 2 give the results graphically. It will be noticed that his errors in reacting increased greatly during the first run and were very erratic. In the

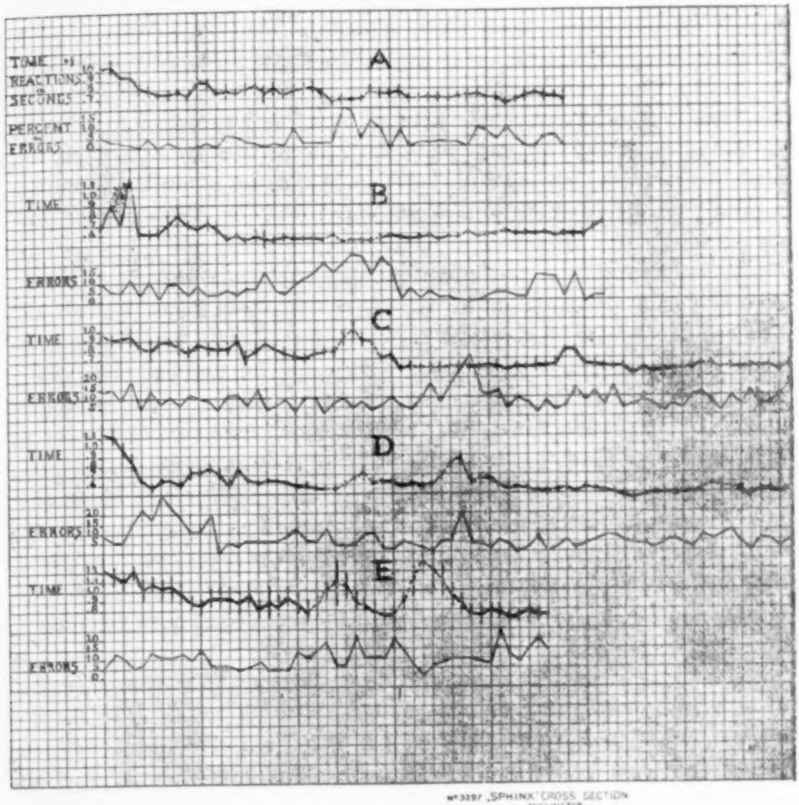


FIG. 2.

The heavy black line represents the average time required to move the controls in response to signals at sea level. The verticals intersecting it indicate the mean variations from the average. The dotted line gives the averages at "altitudes"; the first vertical indicating 6,000 feet, the next to the right, 14,000 and the three following approximately 20,000, then 14,000 and finally at 6,000.

The light line indicates the per cent. of errors made in the responses with the stick and the rudder.

The first "altitude" tests of both A and B show no increase in time required for their reactions, though both scored a larger per cent. of errors. In their second "altitude" tests their promptness and accuracy are quite as good as at sea level.

The learning curve for C and D is longer than for A and B. Two "altitude" tests, made before their reactions had become habitual, show deviations in the time, or error, records from their sea level averages. Their third set of "altitude" tests compare favorably with the sea level tests.

The time averages, mean variations and errors of E show that his reactions were not habitual. Oxygen depletion affected his time of response markedly.

second set of "altitude" series he appeared to be but slightly slower in his reactions, and much more accurate. The explanation of this given by the subject, who is a professor of psychology in a western university with many years' experience, is interesting. He felt that his "range of attention," his "field of attention" appeared to be narrowed when in low air compression. This he thought tended to inhibit distractions, leaving him freer to attend the stimuli. When he returned to sea level conditions he stated that the distraction of his surroundings was greater than under low compression.

This narrowing of the attention may explain a statement which several aviators have made to me concerning their flying at high altitudes. They said that it was easier to fly at these heights because your attention seemed to be on the ship and on nothing else. One naïvely remarked "the earth is so far away there's no use thinking about it." The situation is full of illusions, however, and what a man thinks he is doing when his field of consciousness is actually diminished cannot be trusted very much. When the series under the low compression during the second "altitude" tests are compared with the nine series taken at sea level three days later it appears that the altitude figures are lower than those for sea level. This can only mean that low compression does not affect this man in his quickness and accuracy of discrimination and reaction.

The next subject, B., had also been through twenty-three series of sea level tests before he was given his altitude tests. Like A., he made a great many errors during his first "altitude" runs, but his actual time and his mean variations from that time are not affected by altitude. In his second "altitude" series he made fewer errors but required slightly longer time than in the first set. Six days after the second "altitude" work, his eight *sea level* series give averages for time and mean variations just about the same as his second "altitude," though his errors increased. Here, again, it seems that low pressure and reduction of oxygen to values equivalent to the altitudes mentioned do not result in any appreciable lengthening of time or increase in errors for discriminating reactions.

The third subject, C., required many more practice series before his reactions became automatic. Comparisons of his first, second and third "altitude" runs show a considerable drop between the first and second in time but not in errors, while the third shows a more even distribution of errors and about the same time. Five series taken at sea level the day after the last "altitude" run show a slightly better performance, though insignificant in its difference.

Subject D., also, required a large number of tests before his time and errors reached their minimum. In his first two "altitude" tests

his time of reaction considerably lengthened with the decrease of air compression. In the second series the time is longer and the errors more erratic than in the first. After a number of days of testing the third "altitude" series shows very little increase in time and error over the sea level series which immediately preceded and succeeded it. However, a set of five series at sea level taken the next day show an improvement in both time and errors. This indicates that this subject had not yet quite reached his maximum efficiency. He was still improving upon his time slightly.

With the fifth subject, E., it was impossible during the time available to train him to that condition where his reactions were virtually automatic. This shows in the great number of errors he made, in the very wide mean variations from his time averages, and in the rather extreme length of time required by him for his reactions. In both of his altitude runs there is an increase in the reaction times corresponding to a decrease in the air pressure, a situation quite similar to the first two altitude runs of Subject D.

In attempting to interpret these results we must keep several things in mind. The first is that a man becomes accustomed, in some measure through experience, to altitude conditions. He learns the great secret of deep breathing and he learns to conserve his energy. Furthermore, he is not so disturbed by the symptoms of oxygen hunger and he has more confidence in himself. The more frequently he makes his responses to his signals the more automatic do his reactions become. They may, indeed, as Mr. Gilbert states, result in the formation of a nervous centre which commands the muscles involved in the reaction, "and then of centres in the medulla which become substituted for the brain in a transformation of a sensation to a movement." I question the formation of a centre in the medulla, but it does *seem* as though the higher centres of the brain relegated automatic movements to lower centres. In this case, as the men became automatic in their responses to the signals the oxygen depletion affected them less. Indeed, it would seem as though these lower centres with their simple functions are hardly affected under the conditions of the experiment.

Certainly the higher function of the brain are profoundly affected. This appears from the introspection of the men. They all experienced dizziness and a tendency to vertigo, most of them becoming drowsy and only retaining their control of themselves by concentrated effort. The temptation to doze off is very great. Notice in the specimens of handwriting the misspellings and the repetition of a word, which were undetected while the man was writing. These lapses would never occur if the mind were alert. Obviously the mind is not alert. The best demonstration of that is to experience the change which

comes over one when he has an opportunity to take oxygen when undergoing such an experiment!

The introspections written by the men during the tests are incomplete. It was feared that any special directions might burden them and distract them from the reaction work itself. For this reason they were told to jot down simply those things which occurred to them by way of observation concerning their feelings, emotions, thoughts, actions, as well as the progress and condition of the tests. However, from the notes made some interesting material is available. Three of the men noticed the unique effect of low oxygen upon their moods. Two felt irritable at lower "altitudes," but quite exhilarated at the higher "altitudes." One simply stated that he felt "just fine," though he was suffering from dizziness and a painful headache. The exhilaration somewhat resembles the feeling of well-being incident to an alcoholic drink. Often it is nothing more than a sort of carefree mood. Five out of eight men whom I have tested in low compression noticed this and mentioned it on their own initiative. As one aviator said who had just returned from France, "I felt as though I didn't give a hang." The same idea was expressed more elegantly by a college professor who remarked that he still tried to do his best, but had a "feeling of happy indifference." This emotional condition is one of the most important things to be noted as the effect of altitude. It easily might inspire the aviator to attempt "stunts" his normal judgment would not permit. This carefree attitude, added to the awkwardness of movements and narrow field of attention, makes a splendid conspiracy for a crash.

The aeronautic engineers believe that they are still in the beginning of their science, though they have accomplished a very great deal. Each year witnesses new discoveries and devices. The airplane is being constantly perfected. Obviously, the air service medical experimentalists are at the beginnings of their science. Certainly it is as important as that of the engineers. Some recognition of this fact is conceded by the government efforts in the experimental laboratory and in the work of the flight surgeons. Probably nothing would promote the science of aviation more quickly than a shift of interest from the machine to the man.

# SURVEYS OF THE INTESTINAL PROTOZOA OF MAN, IN HEALTH AND DISEASE

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EVER since the discovery of Balantidium coli in the intestine of man by Malmsten in 1857, more or less interest has been exhibited in this and other species living in the same habitat. For the most part the organisms observed have been recorded from cases of dysentery, diarrhea and other diseases of the intestinal tract, but they have also been found in apparently healthy persons who may act as carriers. A number of investigations have been published, especially since 1914, that add to our knowledge of the distribution of the intestinal protozoa and the extent of infection by them among healthy persons in various parts of the world, as well as among patients suffering from intestinal disorders. Most of these surveys were undertaken with soldiers either in the war zone or in hospitals after their return from the war zone. A few surveys have been made with soldiers before leaving their native country and with civilians, mostly in hospitals. That our knowledge of this subject is still far from satisfactory is evident from a review of the literature. Many species have been seen only once or a few times and hence are not definitely established as such; others seem to be determined satisfactorily but are of doubtful pathogenicity; the life histories of none of the species are sufficiently known to render control measures effective; methods of infection are suspected but not definitely ascertained; the therapeutic agents available are very limited in their application and for most species none is known; and the actual distribution of the different species in health and disease among the general population, with respect to age, sex, race, occupation, etc., is still to be determined.

The principal species of protozoa which have been described from the intestine of man are, among the Sarcodina, Entamoeba histolytica, Entamoeba coli and Endolimax nana; among the Mastigophora, Giardia (Lamblia) intestinalis, Trichomonas intestinalis, and Chilomastix

(Tetramitus) mesnili; among the Sporozoa, Isospora hominis, Eimeria wenyoni, and Eimeria oxyspora; and among the Infusoria, Balantidium coli.

Due to the inaccuracy of present knowledge, there is much controversy as to the pathogenicity of many of these parasites. Entamoeba histolytica and Balantidium coli are parasites of well recognized pathogenicity. Entamobea coli is a well known parasite that is non-pathogenic. Among the parasites of disputed pathogenicity are Giardia intestinalis, Trichomonas intestinalis, and Chilomastix mesnili; in certain localities these three parasites are very common and are supposed to cause severe diarrhea, especially in children. Many of the rare or recently described parasites are of doubtful pathogenicity; there are at least twenty-five species of these, belonging principally to the classes Sarcodina, Mastigophora and Infusoria.

There are also certain bodies which have been frequently found in the feces which are believed by some workers to be stages in the life history of protozoa. The most common of these are Blastocystis hominis, which has been confused with various cysts and has been described as the encysted stage of Trichomonas intestinalis, and iodine bodies of I-cysts.

Statistics from many countries prove that the dysenteries and diarrhoeas are very important causes of death and are especially so in the tropical islands. It cannot be claimed that a majority of these cases are of protozoal origin. It is a fact, however, that we know too little about the causes of these affections and their prevention and treatment. Without knowledge of the real causes and of the methods of diagnosis, efforts at therapy and prophylaxis must be conducted blindly. It appears highly important that we should have more complete knowledge of the origin of conditions which are causing such a large part of our total deaths. Furthermore, the relation between intestinal protozoa and intestinal disturbances that do not cause death nor receive medical attention is in urgent need of investigation. The wide distribution of species of parasites that are passed by unnoticed is evident from a recent study of children in a Baltimore hospital. Here children who were confined for reasons other than the presence of intestinal disturbances were found on careful examination to be infected in a high percentage of cases with an intestinal flagellate, Giardia intestinalis.

A review of over thirty-five papers published by American, English and French investigators during the years 1916 to 1919 describing the results of protozoan surveys has been made by the writers. These reports are based on studies made on all fronts during the war, on examinations of soldiers invalided home for various causes, and on material obtained from various classes of men, women

and children who had never been out of their native land. Most of the latter were either recruits or were confined in insane hospitals or other institutions. Although many of these surveys were not carried out as thoroughly as is desirable they furnish very interesting data and point the way for further research.

Multiple infections, that is, infections with more than one species of parasitic protozoon, seem to be quite common. Thus, Fantham found among 1305 soldiers, 18 cases of multiple infection with Entamoeba coli, Giardia intestinalis and Blastocystis hominis, 20 cases with E. coli and B. hominis, 20 cases with G. intestinalis and B. hominis, and several with E. histolytica, E. coli, G. intestinalis, B. hominis and a spirochete. Similar conditions were observed by Carter, Mackinnon, Matthews, and Smith who recorded 14 different combinations in multiple infections; by Hall, Adam and Savage who reported from 388 convalescent soldiers, 21 with E. histolytica and E. coli, 12 with E. histolytica, E. coli and G. intestinalis and 9 with E. coli and G. intestinalis.

Among the rarer intestinal protozoa the coccidian, Isospora hominis, is of particular interest. This species was practically unknown before 1915 (Wenyon) but was found in no less than one-third of the surveys undertaken since then. Two new species of coccidians have also been added to those living in man, Eimeria wenyoni, and E. oxyspora (Dobell).

The percentage of infection with the more common intestinal protozoa among the twenty thousand cases examined is approximately as follows: Entamoeba coli, 20 per cent; Giardia intestinalis, 12 per cent; E. histolytica, 9 per cent; Chilomastix mesnili, 4 per cent; and Trichomonas intestinalis, 3 per cent.

One of the most surprising results revealed by the surveys under review is the high rate of infection with Entamoeba histolytica among classes who had never been out of their own country or who were not suffering from intestinal disturbances, as compared with patients who had or were convalescing from dysentery and diarrhea. Thus Woodcock recorded 1.9 per cent of infection with E. histolytica among dysenteric Indian soldiers, and 20 per cent of infection among Indian soldiers in hospital for other complaints; Smith and Matthews found 7.5 per cent of E. histolytica among 200 non-dysenteric soldiers; Yorke obtained from 1763 people who had never been out of England, 19.5 per cent of infection with E. histolytica among inmates of an insane hospital, 5.2 per cent among army recruits, and 1.5 per cent among civilians in a general hospital; Wenyon and O'Connor reported 5.3 per cent infection with E. histolytica among healthy men in camps, 13.7 per cent among healthy natives in prison, and 6.4 per cent among convalescent soldiers; MacAdam and Keelan recorded

10.1 per cent infection with E. histolytica among dysenterics, 13.6 per cent among non-dysenterics and 17.8 per cent among convalescents; Baylis (1919) concluded from an examination of 400 healthy new entries to the Royal Navy that from 1 to 5 per cent of healthy carriers of E. histolytica exist in England; Kofoid, Kornhauser and Plate found a greater percentage of infection among overseas troops (10.8 per cent) than among home service troops (3.0 per cent). In certain cases also the records indicate a difference between the infectivity of different races. For example, Boulenger reported almost twice as many cases among Indian as among British troops in Mesopotamia. Thus acute Indian dysenterics showed 48.1 per cent of infection whereas acute British dysenterics, only 24.8 per cent, and non-intestinal Indians 10.5 per cent of infection and non-intestinal British, 6.5 per cent. The results obtained by the various investigators indicate how wide spread are the healthy carriers of E. histolytica and other intestinal protozoa. They also show how desirable are thorough surveys of both healthy and diseased persons in the general population.

It is hoped that discussions such as that presented in this paper will stimulate investigations of the intestinal protozoa and for this reason the following brief statements regarding the purposes and methods of conducting surveys of intestinal protozoa are included.

Surveys of intestinal protozoa are desirable in order to add to the present medical knowledge of the incidence of each species according to geographic range, age, race, and occupation. Our present knowledge of the incidence of the intestinal protozoa is based largely on surveys conducted among troops, the majority of whom had suffered from dysentery or diarrhea of some type. We now require more complete information about the incidence of these species among the general population. The examination of specimens from Maryland and other Southern States by workers in the Department of Medical Zoology of the School of Hygiene and Public Health of the Johns Hopkins University has revealed a high percentage of infection with some of these parasites. A remarkably high infection is indicated also by the reports from the Division of Parasitology of the California State Board of Health as published in their Monthly Bulletin. Data regarding the association of the various species, one with another, and with other entozoa are also much needed.

The degree of pathogenicity of the various species is still undetermined and little is known of the lesions caused by any of them except E. histolytica. In a survey valuable information may be obtained by systematic observation of the bowel condition, the blood picture, the nutrition, and the evidence of the presence of toxic substances as shown by disturbances of circulatory, nervous, or other

systems. Furthermore a protozoan survey would add to the present zoological knowledge of species and their differentiation, and life cycles, especially as they bear on preventive measures, and as regards the appearance of cysts in stools.

Men need to be trained if practical work on the diseases which are transmitted by soil pollution is to be carried on. Before such training can be given we must perfect methods of diagnosis, and investigate the factors involved in prevention. The attention of physicians must be directed to the prevalence of these parasites, thereby stimulating clinical work on pathogenesis and therapy.

The character of the population and the interests of the investigator determine the method of conducting a survey of intestinal protozoa. It is possible, however, to present certain principles that apply to almost any type of survey. If there is sufficient time and enough assistance is provided, a survey of the general population may be made; but it seems best to limit the work to certain classes. These may be selected according to habitat, race, age, occupation, or physical condition. The number of cases necessary to give satisfactory results cannot be stated with certainty but an attempt should be made to examine at least 1000 of each class. The results of various investigations have shown that three examinations of each case give the greatest return for the effort involved. Perhaps the easiest cases to study are those confined in hospitals, insane asylums, and similar institutions. It is desirable however that we know the relation between the intestinal protozoa and the healthy civilian in order to determine the percentage of carriers and their connection with the dissemination of parasites. Another class that is badly in need of investigation comprises the children with intestinal disorders not of sufficient severity to warrant hospital treatment.

Attention should also be directed toward the study of new species and the supplying of additional information regarding those already discovered and named. Such species are almost certain to be encountered in any survey and afford an opportunity to enlarge our knowledge of the group.

Studies of the effects of therapy should be included wherever possible. The control of protozoan diseases depends in large part on the success of these studies. That this subject is recognized as important is evident to anyone who examines the literature on intestinal protozoa that has appeared within the past few years.

The conditions affecting the transmission of diseases caused by intestinal protozoa are also open for investigation. We think we know how transmission takes place, but have very little data on which to base our beliefs. The most important factors involved in their study are probably soil pollution, contact, and insects and other animals.

The viability of cysts under various conditions of excreta disposal offers a simple and important problem for research.

Records should of course be made of each case and should include the name, sex, race, age, occupation and sanitary surroundings of the patient; important facts of clinical history such as dysentery and diarrhea; abnormal features noted on physical examination; and reports on treatment and their effects.

To make a survey as effective as possible it is desirable to properly prepare and preserve for future reference specimens of the parasites found. The best preparations result from the use of Schaudinn's alcoholic-sublimate iron-haemotoxylin method.

The methods of fecal diagnosis employed depend somewhat on the accuracy of the results desired and the ability to obtain and use special apparatus. The Donaldson iodin-eosin-smear method seems to be the quickest and easiest. Concentration methods give a slightly higher percentage of positives and the Schaudinn iron-haemotoxylin smear method just mentioned is very useful in checking up doubtful cases.

Species of protozoa resembling those that occur in the intestine of man are also present in the lower animals and one who wishes to undertake a protozoan survey will find it helpful to become acquainted with these before undertaking human fecal diagnosis. Parasitic amoebae inhabit the intestine of the cockroach, the frog and the oyster; Giardia is common in the intestine of rats; Trichomonas is abundant in the intestine of the frog; Balantidium occurs in the frog and pig; and Coccidia are very frequently present in rabbit feces.

# ON THE CHARACTER OF PRIMITIVE HUMAN PROGRESS

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THE most remarkable thing among natural processes is the unfolding of the intellect and moral nature of man. Since his emergence from the animal state he has possessed powers comparable to those which he now manifests. Neither history nor speculation can reveal a period in his development when he was not making conquests evincing the same high order of intelligence as that which marks even his later career. In the earliest stages the individual man or the small group in a roving tribe had to approach the problems of life and environment without any effective tradition to guide or sympathetic collaboration with others to inspire. This called for a measure of independence unlike anything manifested by individuals today except in the labors of men of dominating genius. Among ruder peoples, in early times and at the present, the remarkable character of the discovery of truth is signalized by the acceptance of the new vision as something supernormal and sacred, akin to the activity of the gods and directly inspired by them. Though we have ceased to refer it to the supernatural, we ourselves understand it but little better.

Confronted with this problem, the man given to creative thinking seems no more able to effect a solution than another. He realizes that he knows not whence his fertile ideas come. Often they seem to spring up in his mind full grown, coming from depths which are not open to the view of consciousness. The thinker can describe some of the conditions which seem to be favorable to the appearance of the idea; but he cannot surely name its origin.

So has it been also in the appearance of the great motive forces which at different times have modified the whole outlook and prospect of human development as a whole. How they were conceived does not appear. That they have effected revolutions in thought and life cannot be denied. Some of the circumstances of their appearance we can see; but we cannot ascertain the prime source from which they sprang.

The first fundamental conquests over material nature, lost in the obscurity of a past from which not even tradition has come down to us, would now afford a sublime spectacle if the eye of history could

find a means to behold them. Standing alone in the presence of nature, enveloped in darkness except for the meager light afforded by the glow of a mysterious genius arising or expanding in himself, primitive man found a means of mastery unlike anything before witnessed on this planet. He took the step on account of which he could cease to be driven about at the whim of circumstance and could introduce into his actions some measure of control over material forces which in themselves were of such magnitude as to overwhelm all physical power in himself and reduce him to mental impotence and mere animality, unless that power were directed by an understanding of himself and of phenomena which was sound in some at least of its fundamental aspects:

It was a marvelous advance when man first realized that he had a power in his being enabling him to bring under control some of these great forces of nature, in the presence of which he had before cowered with fear; and he was a long time in rising to the conception of harnessing these forces to his uses. His earlier advances seem to have been slow and to have been brought about largely by almost accidental discovery. How could it have been otherwise? What, other than unexpected successes, could first have brought man to a realization of the possibility of mastery? What is it in the nature of mind which makes it possible for it to exercise such control over matter? Certainly there is nothing conceived by primitive man which guided him to the realization of his first important successes. In fact, the matter is so difficult to understand that we have not yet formulated a satisfactory explanation, even though for many millenniums man has constantly exercised an increasing control over his environment.

A novel conquest over material things is in itself a victory of mind; and this constitutes one of the central elements in its meaning for the progress of mankind. Certain material things are in themselves essential to our welfare; we must have food and also protection against the discomforts of climate. But, however these may contribute to our physical needs, they can never inspire in us the emotions which constitute our chiefest delights. We instinctively feel that there is something finer in our nature than anything which may be gratified by merely physical satisfactions. The external world and its elements interest us in proportion as they are able to contribute values to our higher life. Whatever may be the material gains arising from increased control over nature—and these are great—more important values overshadow them or displace them in the field of our interest. Until we can extract from the material progress something to advance the interests of our higher nature we feel that it has not rendered us a service of the more vital kind. If the mind has not somehow made a gain in connection with the physical progress the latter is without essential import for us.

Moreover, the physical and the mental, in the stricter meaning of these terms, do not exhaust the whole of human nature and activity. Besides the material and that which is mental in the sense of being actuated primarily by the reasoning powers, there is the realm of emotion and religious experience—what we may call the spiritual aspect of man's nature. We do not understand his development when we leave this out of account. We may tie it up as closely as we please with his physical experience and material environment, we may think of the spiritual as due to a delusion induced in him by phenomena which he does not understand; but we can not dismiss it from consideration. It is one of the great characteristic elements of his nature and must be reckoned with. In fact, it is not too much to say that no element in his development is properly understood in relation to his progress until its colors are seen in the light of his deeper emotional experiences.

The first fundamental step forward in the control of nature, whether taken by the individual or the collective mind, was the most novel mental event occurring after the appearance of life in the process of evolution on this planet. As such it challenges investigation. It marks the beginning of a mastery by the living over the non-living so that the former is no longer to be driven about by the latter but is to come itself into a state of authority. Neither history nor speculation can yield us a well-established opinion as to the stage at which this novel power was first realized by our ancestors; but an analysis of the elements of progress among primitive peoples, both of ancient and of modern times, will help us toward an understanding of this momentous event in our history.

Was the advance first made by an individual who rose far above his fellows and had a grasp of his surroundings unlike anything possessed by his contemporaries, who therefore projected from his personality into the life of man a force which lifted it to a new plane and gave it a new character? Or was it brought about by slow accretions of power accumulated by a sort of collective mind in some advanced tribe which had found a means of preserving its smaller advances and combining them into a whole possessing elements different from any of its parts? Or was it still more complicated than this and required the interaction of tribe with tribe and the accumulation of power through many generations finally to issue in such flower of novel achievement?

The answers to these questions are important for our understanding of the past and of the basic conditions for further progress. The experiments in the laboratory dealing with mental processes are trivial in comparison with this vast social experiment in coming to understand our environment. The former has the advantage that we know the conditions of the experiment; the latter, that the greatest forces of our experience have operated in all the grandeur of their most far-reaching

powers. It is hard to conceive a price too great to pay for a better understanding of this colossal experiment.

Man's environment, both that which he has found in the external world and that which he himself has created, has served to release the powers inherent in his nature. It is this which gives to his deeper understanding of it the supreme significance which we find there. The external world has no power in itself by which it can project a force from itself into the mind of man and create there a new character. Neither is there any such potency in the environment of created truth and spiritual forces with which man has surrounded himself. The power is not obtained from any external source which we can bring under observation, either direct or indirect. Whatever we may think about the question as to whether the native force of man is an endowment more or less supernatural, made by a benevolent Creator, we find no reason now for believing that his acts are merely the direct acts of a Being of higher order operating through him. Whatever is the ultimate source of the power he now manifests, it resides at present in him and is not exerted by a supernatural activity governing each separate act.

This leaves to the environment, then, at most the opportunity of releasing this power and setting it into activity. That it has done this in a marvelous manner is apparent from many considerations, but from none more forcibly than from the fact that a novel material conquest has several times in our long history given a new color to our lives and a different character to our outlook.

What stage of development have we reached in this process of unfolding? What proportion of the native endowment of man has already been realized by completed achievement? How nearly has he gained his maximum control over his environment? To what has he reached relative to the fullness of his being, in the understanding of his own nature and powers?

On our answers to these questions will depend the character of our outlook on the future of the race, as to whether it shall be optimistic or pessimistic. If we feel that all, or nearly all, of the fundamental conquests have been made, there will be nothing left to us to give zest and meaning to our lives. No vision of great things to be achieved will stand out as the goal of our labors, inspiring us to efforts realizing the greatest force of our character. As a race we should cease to live in the future or rejoice in the visions of things to come; the activity of life would lose much of its charm for us and we should find our greatest comfort in meditations on the achievements of our ancestors. Nothing could more clearly indicate that the race had come to the period of old age; and we could hardly prevent the feeling that the time of its end was drawing near.

On the other hand, if the evidence should indicate that we are still in a stage of active development and that there is every reason to ex-

pect further advances, comparable to the greatest of the past, then the joy of life and labor will spring up and we shall take hold of our several duties with the spirit which arises from the conception of the most worthy things to be achieved. No labor will seem too long or task too arduous if it promises to lead us forward to a realization of things hoped for. Many workers will be ready to consecrate a life of intense application to the study of phenomena of every sort, however far some of them may be removed from the previous interests of mankind. No opening into the unknown will be so obscure or the prospect so dark as to drive away all thinkers. Every possible line of progress will be explored under the enthusiastic hope or expectation that something of value will be found on the way; and man will rejoice in his progress in fields for a long time cultivated and in territory just being opened to exploration.

It is clear that man must somehow obtain power, not merely latent but active, before he can enter upon a control of nature such as he has achieved. No measure of inherent possibilities will be sufficient. They must be realized by an actual grasp of present power in a state of successful activity. It could hardly be conjectured, and there is no reason to suppose, that the release of his energies was sudden like that of a coiled spring. It is far more probable that the process was a gradual one and that the accumulation of power would be better illustrated by the slow increase of force in a water turbine into which is admitted an increasing stream of water from a head which does not sink but perhaps rises slowly. In this figure the effect of the environment is represented by the action of the gate through the slow opening of which an increasing portion of the power in the head of water is admitted to the turbine and is thus released into effective work.

In our present state the greatest inspiration to an intellectual life and hence to an increase of power comes from the interaction of mind with mind. From its very nature this is the kind of influence which the individual primitive man would first be able to realize; for it is an influence emanating from that which is most akin to his own activity and consequently best able to find a means of entrance into his experience. This would lead us to expect that the first fundamental advance would be intimately connected with the relation of man to man in his mental life. Such indeed have been the conclusions of anthropologists, after a careful examination of the relevant facts. To the development of language, the prime means of the communication of mind with mind, has been given the honor of initiating the marvelous release of the powers of man.

Language is so intimate to the deeper experiences of the mental life and exercises an influence so definite and so characteristically its own over the development of an individual that the universal realization in mankind of such effects as it produces tends to increase in

a marked degree the essential unity which has its origin in the common ancestry. If language had its beginning in a single center—perhaps the first home of the race—and spread thence throughout the world, then its unifying influence would have the additional effectiveness gained through the transmission to all mankind of the ways of thought first crystallized into its words and forms of construction.

That this unifying influence is highly effective is still manifest today. In many ways we see common elements in the civilizations of peoples possessing a common language which have a tendency to disappear if from any cause one of them comes to use another language. Conquerors have often realized this and have frequently sought to adjust a people to a new rule through forcing upon them the language of the conqueror.

There is a matter of a subtle nature in the way in which language makes it possible to pass the experience of one generation along to the next. The phenomena of nature present themselves to us ordered in space and time, but without apparent logical connections to bind them together. As long as we meet them merely in the multiplicity of their separate existences we can not get far towards an understanding of them or a mastery over them. It is necessary that they shall be ordered into groups or sets each held together by some tie which serves in our minds as a unifying element. Now the combination of distinct elements into a whole and the formation of these groups depends on a process which the mind constructs for itself slowly and only after much labor. Any means of giving a considerable measure of permanence to the constructions of one individual mind or of one age will be of great value in maintaining mastery and effecting its further development.

Now when a tribe of men reach agreement concerning the common elements of a set of objects, as for instance the trees in the forest, and signalize their realization of the common features possessed by them by giving to them some such name as *tree*, they crystallize into definite form a class of experiences felt by each of them in a more or less vague way. The idea denoted by the word becomes more distinct by constant recurrence and both word and idea take their places as part of the mental possessions of man.

Now a word into which so much experience of the race has been instilled can easily be taught to the children of a new generation and be made to serve for them as a nucleus about which they can gather experiences of their own similar to those first embodied in the word. Thus through the various words which they use they have a very subtle means of assistance in organizing their early experience so that they are able to make much more rapid acquisition of knowledge than their ancestors who first had the confusion of unorganized impressions out of which they must construct the first essential organization of truth.

There is another advantage, lying deeper than this need of understanding the material environment, which language brings to the new generation. The way of thinking of their ancestors is preserved in some measure for them in the constructions of their language, in the peculiar ways of expressing thought developed through ages of progress. Thus a certain significant part of the mental development of mankind is summarized into the form and words of language in such a way as to be capable of transmission and to be of unmeasured value in passing on to the children the acquisition of their ancestors.

It is clear that this thing which is of so much value in one respect has in it otherwise certain elements of danger. The prejudices of the past are transmitted along with the accumulated truth. But, in the whole process, the good far surpasses the evil, leaving a large balance on the side of progress.

Among the savages who first developed effective language there was a force of intellect not to be despised, by whatever standard of achievement it may be measured. That it grew up probably by slow accretions from age to age does not detract from its marvelous character. It means merely that it was a product of the collective rather than of an individual mind, as from the nature of things it was necessary that it should be. To separate out ideas of far-reaching importance in practical life and to agree to associate them permanently one by one with such fluid and evanescent things as sound symbols which should call them to the mind of every hearer acquainted with the language was an act which could be performed only in the presence of a deep understanding, dumb though it may have been, of the essential elements involved in the process.

In view of this first magnificent creation of the primitive mind we can not refuse to recognize that early man possessed powers which do not suffer in comparison with those manifested to-day. To be sure, he was in the presence of an environment of which he had little detailed and established knowledge and some of his conjectures went wide of the mark; but, without any tradition to guide, he went about the creation of those means of communication which have since served us in all our activity. It was a long time before systematic methods of investigation were developed; but here at the beginning we see at work the instinct to discern and to grasp the deeper essential matters, and we find it issuing in the wonderful invention of effective language.

Fire occurs in nature. Now and then it is kindled by the lightning from heaven and consumes the forest tree or even sweeps the woods in devastation. Or it may bound forth from the bosom of the earth in volcanic eruption and destroy everything in its path. To the primitive man it was doubtless at first a consuming monster; and he must have stood in awe of its mysterious power. But a tribe which hunted in the neighborhood of a volcano, whose action was regular,

would become familiar with it and would learn to appreciate its warmth on a cold and dewy morning. Gradually its value would be perceived and after a time the more adventurous spirits would begin to experiment with it and even to bear it about with them on a burning fire-brand, notwithstanding their occasional experience with its terrible bite. In this way a realization of its uses would begin to develop, and the community as a whole would gradually find new values in the tamed monster. The process was one carried out perhaps essentially by the collective mind of the tribe rather than by individual initiative.

The idea of accumulating power through a long process of tedious labor and storing it, as it were, so that it might be released suddenly with almost explosive force was perhaps first realized in a large way in the invention of the bow and arrow. The significance of this achievement was three-fold; in itself it afforded a remarkable means of mastery over a certain part of the environment; it predicted the discovery of further means for the multiplication of power; it gave man a new sense of the dignity of the character unfolding in him.

These three values are in the order of increasing importance. They exhibit a feature common to all the more profound elements of human progress, namely this, that the scale of values increases rapidly in the direction of a greater emphasis upon mental or spiritual forces. Often it happens that what is material lies close to hand so that it is the first thing found on a superficial examination; but lying deeper are movements of a more profound nature affected in some essential way by the results of the material development and affording to it its principal significance. In order to understand the progress effected one must ascertain the meaning of these deep-lying elements and the way in which they bring about an increase of power or the development of character.

The bow and arrow does not occur in nature. There was a moment when it was used for the first time; in the nature of things it must have been an individual, and not the tribe or community, that made this advance. The original weapon may have been of the crudest construction and have been used merely as a toy; but there was wrought into it the one novel idea which has guided in the making of the most perfect instruments of its class. Whether the idea was arrived at by accident or by deliberate thought, we have here the introduction of a thing of prime importance due to individual achievement. Language was developed and the uses of fire were discovered through the combined activity of the community as a whole; but the invention of the bow and arrow must be assigned to individual genius. It seems to be the first important instance of a kind to be found with increasing frequency as the consciousness of the possibility of such achievement becomes more definite and more widely current and as in-

dividual thinkers set about the labor of creative thought with clearer purpose as to the ends to be attained.

The experience of mastery over the clay which took form at their wish and was rendered durable by methods constantly practiced by them, awakened in our ancestors a conception of their power to mold things according to will and to create that which would endure indefinitely. Through this they realized a new possibility in human development and began to reap the fruits of a further release of inherent power.

In their previous progress our ancestors had merely effected new juxtapositions of materials already at hand, as for instance in the construction and use of the bow and arrows; but now in the pottery which they had learned to make they had brought into existence a sort of material not previously to be found in their environment, perhaps not anywhere in the universe—a conquest the novelty of which has since seldom if ever been equalled in the ages of increasing control over nature. Our modern laboratories have carried the processes of the creation of new materials beyond what could have been predicted by the most optimistic prophet of the old time; but in doing so they have only developed the idea which was brought into partial realization by the genius of a remote people.

It appears that the intellect which made the first fundamental advance of this sort was certainly possessed of essential qualities of power not unlike those which have led in recent generations to that development of physics and chemistry which is the marvel of those who take an intelligent interest in man's success in understanding the relations of phenomena in his evironment. There has been a development of mind, there have been acquisitions of new power, especially through a more profound grasp of the essentials of method in discovery; but the fundamental basic qualities of intellect now and in the remote age when the art of making pottery was acquired seem to be of the same nature.

We may take pleasure in such ancestors as our forefathers showed themselves to be even in the periods of savagery and barbarism through which we have rapidly sketched their development. They stood in the presence of phenomena whose nature was awe-inspiring to the creature that first inquired concerning their meaning. With no traditions to assist, with no previous conquests or discoveries of truth to start them out, with only a dumb and undeveloped sense or instinct of the destiny of man to light the way into a darkness of ignorance more profound perhaps than we can conceive to-day when so much of the push of the past has already been realized in our individual lives before we come to contemplate philosophically the nature of our environment and our relation to it, they began a career of development to which nothing else in our ken is to be compared.

# SELECTION—AN UNNOTICED FUNCTION OF EDUCATION

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ALL discussions of education, ancient as well as modern reiterate the belief that education is essentially a process of creating intelligence. They assume that a man with no intelligence, if such existed, might be taken by a suitable educational system or machine and in the course of a few years be given a capacity equal to any, while without it he would remain forever unintelligent. This assumption undoubtedly is in partial harmony with the facts. It, however, neglects one phase of the effect of education that is equally true and perhaps even more important, the fact that education merely selects the men who are capable. Instead of taking all men without respect to intelligence, and making those who go far enough intelligent, it takes all, but rejects the unintelligent and graduates or even trains only the intelligent. The educational system does not create capacity, it merely or largely selects the men of capacity.

Back of most of the popular and even many of the technical arguments on educational topics is the assumption that all men are equal in ability, and that what differences exist, are the result of training and of chance factors in the environment. Recently evidence has been accumulating that by nature men have all degrees of intelligence. A few with little training accomplish much; many with all the training of which they are capable never rise to mediocrity. As opposed to the popular belief it is our intention to present the thesis that men are as different in intelligence as they are in stature or as in length of life, and see what conclusions follow.

Only within the last two decades, and mainly within the last few years, has it been possible to obtain any direct experimental evidence of the way intelligence is distributed in the general population. With the development of a psychology of mental measurement, and the wide application of the measures, we can begin to discuss the problem with some basis of fact. To silence criticism by granting the lesser claims of critics and insisting only upon what is assured, we may admit that there are many defects in all the measures that have been applied and that many of the advocates of particular methods have claimed too much for them. We have only the vaguest notion what intelligence is. Our measures serve to distinguish only the more marked differences. We still lack any sufficient criterion, aside from

the tests, of what an individual whom we have assigned a position by our measurements will be able to accomplish in any standard practical task. Still they suffice to show what wide gulfs divide the highest from the lowest and even the extremes from the average. We can say in answer to any criticism that psychologists know much more of all this than do the popular writers on educational topics.

In the recent army tests conducted by a number of psychologists and helpers, a million and three quarters men were tested by the same measurements. These were draft men chosen at random, except that the army surgeons were supposed to have eliminated all the mentally defective and inferior. The results of tests were carefully computed and correlated for one hundred thousand men of English names chosen at random from the list. These in turn agreed with and so confirmed the results from other groups similarly treated for preliminary reports. The tests used were also compared with other tests that had been applied to the measuring of a large number of school children, so that indirectly there are a number of cross checks on the method and a possibility of comparing the results obtained with those gained from numbers of school children.

Taken at their face value, the tests give a definite indication of the way the intelligence of the nation is distributed. Even if the tests were sometimes not so very carefully made, as is likely from the number of men who gave them, even though all were thoroughly trained in advance, they still furnish a general idea of the great range of intelligence in the male population. The army tests consisted in part in following directions for simple tasks, perceiving relations, performing simple arithmetical computations, putting words together to form sentences, detecting misstatements, and answering question which measure general information. Altogether an individual might make a score of 212. No one had time and information to answer all. Only 135 was required to attain the highest or A grade. This probably redeemed many of the apparent absurdities of the tests. Some of those, particularly the questions intended to test general information, were of a character that gave no particularly good indication of useful knowledge. With so low a standard, any one should have been able to answer a sufficient number to atone for failure on questions that ought not to have been included in the list.

On the basis of the tests, men were divided into groups that were designated at A, B, C+, C, C−, D, and E. These were defined in terms of ability to reach certain grades in the school system, partly because that offered a convenient means of labeling, and in part because it corresponded on the whole to the grade the men had actually attained. The A group of five or six per cent. do well in college. The B men are less successful in college but do well in high school. The C+ men complete the high-school course, the C men rarely do. The others

would not be able to go beyond the grades, the E men not beyond the third grade.

One other convenient and frequently used means of defining or describing intelligence should be mentioned, as we shall have occasion to use it. This is Binet's scheme of measuring and grading intelligence in terms of the stage reached by a child at each year of his age. In the measurement of the feeble-minded, he compared the success of the individual to be tested with the success of the children of different ages in the same tests. Thus we may speak of a mental age of seven, ten, or twelve, indicating that the individual, irrespective of his real or chronological age, has the intelligence of a child of seven, ten, or twelve. And the D. group in the army tests might be said to have a mental age of eight, the E, of seven or below. The average mental age of adult whites of English name was a little below thirteen years.

The most plausible interpretation of the results of these tests indicates that on the average the stage in the school system attained by the average individual corresponds roughly with his capacity. It might be argued that the results of the tests were due to the amount of training given in the schools. That this is not the case seems evident from the fact that the tests were chosen so far as possible, with the intention of requiring no knowledge that would not be thrust upon any individual who lived in the average environment. They were planned to measure ability and not knowledge. It is also confirmed by the fact that a few men who had no educational advantages stood among the highest. They were men from isolated communities who had had no chance to attend school, but who would undoubtedly have done good work if they had been given an opportunity. The close agreement with the grade reached in school is, we may believe, due to the fact that most Americans go as far as they can in the school system, so that the amount of education is pretty closely related to the degree of natural intelligence. Had the men who stood first never been inside of a school room, they would have done as well in the tests as they did. Or, to put it less strongly but in a way that is practically the same from our present point of view, having the ability that they had and living in the social environment that they did, they were sure to reach the school grade that they did.

Accepting these results for the sake of argument, we can draw many interesting conclusions concerning economic and political problems, as well as concerning the problems of education with which we are now dealing. If we have a body politic in which only fifteen per cent. of the citizens can be expected to make any important contributions, and possibly not more than half are able to understand clearly the real problems of the state, have we the machinery for selecting the men who are best fitted for the higher grades of work, or are we al-

lowing our best to waste time with unimportant affairs while lesser intelligences are struggling vainly with the great problems.

We may make illuminating comparison with what was probably the most detailed selective system ever applied on a large scale, the scheme put into effect by Suleiman the Magnificent in the sixteenth century when the Turks were at the height of their power. In broad outline this was completely democratic in the process of selection, although put into effect by one of the most thoroughgoing autocrats of history. It will be recalled by readers of Lybyer[1] that officials and soldiers were chosen for the imperial household from among the best children of the Christian population, and were taken to the court and there systematically trained in the line for which they showed the most aptitude. Agents went through the entire realm at regular intervals, examining the boys between ten and twenty and choosing the most intelligent, the strongest and the fairest for school. Slaves in name, in reality they were students and potential rulers. Once entered in the college of pages or in the corresponding school for soldiers, nothing but their own endeavor and own capacity was permitted to decide how far they might rise. They were slaves in status and worked under compulsion. When started on the career, they had no alternative but to do the best in that line. They could not escape if they would, and there was a fair field and no favor, with the possibility of great rewards and high distinction for the few who showed themselves capable. Selection and the strongest possible incentives, all worked together to make the ruling body and the soldiers of the Ottoman Empire the best that could be provided within the limits of the realm.

This was probably superior to any of the other methods employed at that stage of the development of the world's history. It is due to this rigid selection, probably, more than to any other fact that the Turk came near conquering Europe. Certainly the average ability was no higher, if we may judge from the later course of the empire, than in other portions of Europe. The education was rigidly enforced and was intensely practical. But no one could contend that the education developed the ability. Only the pages who were destined for the offices of the household were taught to read and write. These were also trained in the Turkish law, in the religious books, in the literature of Arabia and Persia, with some smattering of history. All were given rigid physical training, were taught a trade useful in war and one that might at need be relied upon for support.

The rigid selection of the physically and intellectually best was the essential factor. There were numerous grades in each service and a student could rise from one to another only as he excelled in

[1]Lybyer, "The Ottoman Empire in the time of Suleiman the Magnificent."

the lower. Advancement through these grades to the highest places was possible in any service. There was no favor, and any man could rise to the highest position, granted only that he had ability. We have good reason to believe that the power of the Turk depended very largely upon this system of selection, not upon education. This selection was not complicated by any favors to sons of powerful men; since only Christians were chosen and they must become followers of Islam when they were inducted, their sons were ineligible to succeed them. Coupled with early selection of the best was full opportunity to attain the position for which the individual's talents fitted him, with rich rewards for the successful ones. Education may have counted for something, but however important the thorough military drill and the vigorous physical exercises, it was hardly suited to work wonders in what we would call intellectual training.

Is there a similar selection working in a democracy such as we have in America? There is not and probably could not be developed a system that would select youths for training of different forms; that could say to one boy, "You have promise and will be given the training and opportunity of trying for high office," to another "You have only manual skill and shall be trained to a skilled trade, with only sufficient literary education to enable you to read and be a good citizen," and to a third, "You have neither mental ability nor manual skill and can only be an unskilled laborer," and so on through the list, prescribing to each the occupation he shall follow, based upon test or study of his capabilities.

On the other hand, many of the agencies that we regard as having other functions do really serve to sort and sift, and many of the advantages that come from these agencies are due more to the selection they work than to the training they give. The official agencies such as are provided by the civil-service examinations, act too late and are too superficial in operation to have any marked influence. They select on the basis of knowledge rather than ability and are so carelessly administered that they do little more than take the place of the politician in choosing by chance more than by favor. Their only positive advantage is to break up political machines and to prevent the obviously and grossly unfitted from securing positions.

More important and more long continued in its action is the system of education. Although the educational system is supposed to make intelligence rather than to select it, it is certain that selection is a most important feature, even if no attempt were made, as might with considerable plausibility be done, to argue that the primary, if not the exclusive, function is to discover rather than to create, or even to train, intelligence. In any state with a compulsory school system, all grades of intelligence are fed in at the bottom. The worst of them repeat the lower grades, and even with the kind-hearted or

indifferent teacher of the least modern school, or of the most modern who works under the training-school dogma that the child should determine the character and amount of instruction, the inferior are excluded after three or four grades. In the more modern schools, tests select these incompetents earlier and they are given training adapted to their capabilities and are not expected or permitted to follow the regular curriculum. They graduate into the ranks of unskilled labor and can never expect to do more than earn a living. Society can ask only that they develop habits that will permit them to live in society without becoming criminals or paupers.

The higher capacities are sorted roughly by the regular school work. Those who find study too hard at any stage drop out and go to work, and when freed from the necessity of attendance at fourteen, only those of more than average capacity are left in the schools. Only the chosen upper 25 per cent. or less can reach the high school or go far into it, and about twenty per cent. do. Of these about half are eliminated before the high school years are completed. A still smaller percentage reaches the universities or colleges of the country. The educational system may be regarded as primarily a sieve for the separation of the competent from the incompetent. It would be very interesting to know if it is effective in this respect, and whether it alone suffices to put the administrative offices into the hands of the best.

Common observation indicates that there are other forces at work in the selection of individuals for the higher educational institutions than the mere ability to pass the work. The cynic can see evidence of the operation of at least two other forces. One is the wealth and advice of the parents, and the other, the social esteem in which education is held by the different grades of society. Certainly the son of a wealthy man is much more likely to go to an institution of higher learning than is the son of a pauper. Even in the least expensive of universities some reserve money is required. At the best, only the youth of exceptional energy as well as exceptional ability will be able to make his way through college without some backing or accumulated family capital. If he could take care of himself, it not infrequently happens that he will have the family in part dependent upon him, and so part of the selection is at best determined by the family finances rather than by sheer ability.

One can argue, and with plausibility, by the support of what statistics are available, that, in the long run and on the average, the men whose fathers are at least moderately well off are more likely to possess a higher degree of intelligence than are those who come from homes of poverty. Accidents such as the death of a parent may well account for families of good ability being without resources. At present, too, the men who go into the professions of teaching and preaching, no matter of how much ability or how successful, seem

fairly certain to be unable to educate their children from their earnings. But, on the whole, while selection on the basis of wealth would tend to eliminate some who might succeed, it would not prevent the college men from being a chosen group.

The number of people who go to college would on the whole correspond fairly closely with the number who were capable of profiting by a college education. On a rough calculation, assuming on the basis of the army tests that 10 per cent. are capable of profiting fully by college education and that one twelfth of the population is between the ages of eighteen and twenty-two, we would have less than a million who are capable of doing college work. Of these, approximately a fifth are actually in college or have been in and withdrawn. If no more than four fifths of those capable of profiting by training are lost, we may not be able to boast of perfection, but may be reasonably satisfied, considering the defects in our knowledge of most of the factors that must be considered. This selection may be regarded as fairly effective in spite of the limitations imposed by the varying wealth of the population and the dependence, in some degree, of possibilities of education upon wealth—in spite, too, of the limitations imposed by the uneven development of the schools, the discouragement that comes from bad temper and incapacity on the part of badly selected or poorly trained teachers, and all the other circumstances which may be regarded as chance.

Running parallel with this is selection of the opposite type. In many classes in America, there is a constant temptation to enter occupations that give immediate monetary returns. Many boys in the teens try business and trades for a time in vacations. Many, if not a majority, of the college men in America pay their way, in part at least, by odd jobs during vacations, or in the odd hours of term time. This brings a constant temptation to the more successful to continue permanently in what was accepted as a means to an end. Emphasizing this aspect, one might regard the men chosen for education as the men rejected by the skilled trades. It is undoubtedly true in an industrial community of the middle class that many of the boys try the trades and those who succeed best remain, while the others go on with their studies. In some cases physical handicaps, like the loss of a leg or an arm, will force a man to become a member of the learned professions. Usually, however, the professions are regarded as more honorable and desirable in every way, and this social prestige counterbalances immediate present success. The men of the better mechanical ability, or the men of better address and natural skill in dealing with people, are often trapped by too great initial success, and with the slight training in fundamentals which they have obtained at that time can go no farther than the business into which they have entered will permit. Those who do not chance upon a position early

in which they can succeed without training go back into school and continue to the end. It is of course extravagant to say that the professions are filled with the individuals who are rejected by the trades. On the average the selection is the other way round, but, that selection by rejection from the more immediately practical occupations exists, can not be denied.

On the whole, however, there is from this lot rejected by industry another sifting by the need for success in school, which leaves only those who are superior in intelligence, as well as those not particularly skillful mechanically in the list of college students. Then, too, the wealthier men are not tempted by industry although they may be by business and "society" or by mere desire for pleasure without responsibility. These are drawn to educational institutions, first, by the social prestige of the college, and, second, by its reputation as a place for a good time and as a desirable place to make acquaintances. The university or college may do these men no good, but at least their presence insures that the college shall contain a fair sampling of the men of higher intelligence chosen even from the most wealthy classes, from those whose families have been most successful in business, and who, if we accept the two assumptions that the wealthy are the intelligent and that intelligence is inherited, should average among the most intelligent members of the population. From this group come probably a fair number of the professional men, and especially a large proportion of the men who are to conduct the big businesses, or the not inconsiderable number who have not been selected by actual success in the business world itself.

How great is the part of the university in the selection of the men for the prominent places in the general community is evident from the statistics printed in the 1910-1911 edition of "Who's Who in America." This shows that fifty-eight per cent. of the men listed were college graduates, if we include the military men who are graduates of their technical schools, and that seventy-one per cent. had attended college or university for a longer or shorter time. Only ten per cent. had nothing more than a common-school education, and less than one per cent. asserted that they were self-educated. Whether selection or education is more important, the effect is wrought through the educational system. Of course it might be asserted that the 17,000 men in "Who's Who" indicate only a small fraction of the men who are filling important positions and that an undue proportion of these were in literary and academic pursuits, just as on our assumption it represents only a fraction of the men who are capable of attaining prominence. It is fair to say, however, that the proportion of college to non-college men who are in similar positions who are not included in that list will probably be approximately the same as in the list. Our first assumption that twenty per cent. of the men selected for the

highest positions are chosen through the educational system seems rather an under than an over estimate.

The other forms of selection are through success in some particular occupation. In every large business there is a constant stream of men who rise from the ranks, and a large proportion of the successful men, who acquire wealth and position and thus become prominent in society or in politics, are chosen in this way. These are made up, in part, of men of high intelligence who for some reason dropped from school early. Many undoubtedly have capacities that would not have led to academic success but are valuable in business. How many of the latter type there are, and what constitutes the means of selection or the measure of ability is, most probably, value to the business in the opinion of the immediate superior. In many departments we find in the amount of business secured or in the actual accomplishment in the individual's own business objective measures of ability. All of these embody tests of energy, of push, and of social capacities that are not involved in the university work or are not important in the same degree. We know only that intelligence is required for a high degree of business success, but courage and energy may compensate in some degree as they cannot in the higher school work.

What relation there may be between success of this type and what we call intelligence as measured by scholastic work, is not definitely known. Probably successful business men are a mixture of those who succeed because of good intelligence, mixed with a certain amount of persistence and fighting qualities, of those who have considerable fighting ability and less intelligence, and of those who know how to get on by taking their opinions and aims and methods from successful men about them. One of the most successful of modern manufacturers showed in a recent court examination that he would not be able to pass at all one of the tests most relied upon in the best known series of mental tests, that of making definitions of abstract terms. Of course, the tests are not so well established that we can regard that as evidence of his defective intelligence rather than of the unreliability of the test. Certainly, if we are to prove that certain of these men lack intelligence, a large part of the population would regard it as a proof that intelligence is an undesirable characteristic.

Very interesting would it be to raise the question whether intelligence is closely correlated with wealth. On the whole, there can be no doubt that the two are connected. We find an occasional exception in individuals of markedly low intelligence who have accumulated considerable wealth, and we have the testimony of Charles Francis Adams that the men of wealth are on the whole stupid. As statistical evidence is the fact that several surveys of the well-to-do

neighborhoods indicate that the children there are mentally a year older than are the children of the slums of the same chronological age. This of course, is a comparison between the poor and those of average wealth, but has a bearing upon our problem in so far as it indicates that the well-to-do are more intelligent than the poverty stricken. On the whole it would seem that while a modicum of intelligence is necessary for great wealth, other factors are important Some of these are beneficial to society, others not. Among the most important of these qualities are initiative, persistence, social address, acceptance of conventional ideals, and in many cases an emotional defect or defect of imagination that impairs sympathy for the victims in those instances in which wealth is won at the expense of others. Many intelligent men think that acquiring wealth is not worth the effort required and prefer to apply their energy in other directions; many lack the immediate opportunity, and still others are disturbed by the thought of the men who may suffer in the process. This last attitude is well illustrated by a student who explained his failure to succeed on a summer canvassing tour for an article of luxury, by his inability to talk enthusiastically when he knew that the people to whom he was trying to sell really needed their money for the necessities of life. Men selected for great wealth are above the average in intelligence, but wealth is not a direct measure of intelligence.

We can picture the educational system as having a very important function as a selecting agency, a means of separating the men of best intelligence from the deficient and mediocre. All are poured into the system at the bottom; the incapable are soon rejected or drop out after repeating various grades and pass into the ranks of unskilled labor. The really defective go at once to the homes for dependents and to penal institutions. We are frequently inclined to forget that almost half of our criminals and most of our paupers are mentally deficient. A teacher of an ungraded room in a western city school was twitted by the county attorney with graduating her pupils from the school to the juvenile court. The more intelligent who are to be clerical workers pass into the high school; the most intelligent enter the universities, whence they are selected for the professions. Up to this point the sifting process works with an accuracy that approximates twenty per cent. At least one fifth of those best fitted intellectually find their way to college. Of the best who are shifted into practical work before this stage is reached, some work their way to ruling positions in business and industry, or develop through irregular means into professional men. Others become politicians, to which career neither law nor custom sets definite requirements for admission.

After the university man has been selected by the educational system for his intelligence, coupled to a certain degree with the per-

sistence and other volitional characterstics needed to make his intelligence effective, he must again be passed upon by society at large for his social and more human characteristics. More than a few well-trained physicians fail to obtain patients because they can not inspire confidence in, or arouse antagonism from those whom they would cure, and great success at the bar or as an engineer is only for the relatively few who are selected for social and personal qualities from those passed as competent by the schools. This makes necessary the training of a much larger number of men for each profession than is really needed in the profession, and implies much waste of time and of emotion on the part of the men who are rejected at this final stage. Not all of the training is lost, for it may be applied in other ways. At least no way to prevent it is at present available.

In emphasizing the selective phase of the effect of education, we have no desire to minimize its importance in training or in supplying needed knowledge. Undoubtedly there are ascribed to training many of the advantages that are really the effect of selection, but were the most brilliant men prevented from acquiring knowledge, they would have relatively little capacity. Were the most intelligent man to begin without a knowledge of what had been acquired by earlier generations, he could go no farther than did Thales or Socrates, who would certainly rank well with the highest intellects of this or any other time. Some of this knowledge could be and is picked up from books, more from the activities of everyday life in an environment made possible by and altogether dependent upon the instruments devised by predecessors and contemporaries. Complete mastery is certainly much easier to obtain through, if it does not actually require, systematic training that can best be had in a regular educational institution. Knowledge of methods, of the best usage in every field, comes more surely and easily through instruction of the formal type. Contact with others who are doing the same work is not a small factor in real training. We are not in a position to deny that there may be some general effect of training that may make the individual more effective everywhere because of the habits and particularly the ideals that have been acquired in one restricted field. Our only thesis is that much of what we are accustomed to ascribe to the improvement of the individual through education is due merely to the selection through the educational system of those who were fitted by original endowment to accomplish the tasks we would set them. It should be insisted that this is no mean function. To select the men who are capable of training, even to select the men who are capable of the highest accomplishment, even if their capacity was not increased in the process, is a function of the highest importance.

There can be no doubt that the fact that selection is confused with

training constitutes an important fallacy in most educational arguments. All advocates or apologists for educational systems or methods are wont to point to the product as a justification of their existence. The argument is advanced for the Chinese as for the medieval, as well as for the tripos at Cambridge and the honor course at Oxford, to come no nearer home. Each could point to the fact that most of the men who won distinction were products of the school system. We find and are willing to accept the statement that the most successful Indian civil servants are men who stood well in the mathematical tripos, and the implication is that they are excellent civil servants because they studied mathematics thoroughly and successfully. The conclusion is usually drawn that all civil servants should have an equally thorough mathematical training in order to create or develop the power of governing. We are all willing to accept this conclusion. Less evident to the occidental seems the corresponding argument of the Chinaman that true greatness can be the product only of spending years in committing to memory the works of Confucius, although as arguments both are on a par. Each neglects the factor of selection. The mathematical tripos selects men of the highest capacity, perhaps of the highest capacity peculiarly fitted to the exercise of the functions of a civil servant. The Chinese system also selects superior men for the governmental positions. There is nothing in the argument and little in the inherent probabilities of the case to convince one that could these men have been selected in any other way without a knowledge of mathematics, they would not have been just as effective. This confusion of selection with training is what saves ineffective systems of education. Whether they improve the individual who goes through them or not, they do sort the capable from the incapable, and training is given the credit that belongs to selection.

It might be questioned whether it is worth while to spend so much time in selecting through the slow process of the school system if selection is so large a function of that system. One might urge that we develop a set of tests similar to the army tests and apply them to the youth when they present themselves at the kindergarten and then assign them to the form of instruction that they would be capable of or that would prepare them for the function in life that is suited to their abilities. Did we have tests that were accurate, and were there possibility of revising the rating to make allowance for change with increasing maturity, a good case could be made for the early selection. In fact it is already being introduced in varying degrees in several cities. Most now have some degree of elimination of the most feebly endowed from the regular classes, with special more suitable training that shall give the minimum of academic and a maximum of practical work. A few are attempting to make other classifications on the basis

of intelligence as determined by test. Both have proven satisfactory so far as developed and more use could be made of them did we have the proper machinery.

There are grave objections, however, to a complete control of selection by one individual or agency, even assuming an entirely adequate system of tests and perfect competence in the administration of them. As it is, tests have, at most, a general significance. They suffice to recognize large differences fairly accurately, but at the border line where small differences are significant they would work many injustices. The effect upon the individual who was misplaced downward would be disheartening, while for the men who were encouraged to go on for work beyond their powers the system would have no advantages over the present method. The present general belief in equality of capacity with the correlate of equal opportunity provides an incentive to endeavor that cannot be overestimated. Were one to be told authoritatively that one had no chance to be more than a day laborer and would be permitted to learn no more than was necessary for that, and was by law prevented from attempting to fit one's self for anything better, most of the joy of living would be eliminated. It would be much worse than to be told that one belonged to an inferior social order. The present system gives occasional reminders that one is not of great ability, but there is always chance of mistake, and the general belief in equality serves as a consolation as well as a constant spur to endeavor.

As compared with the organization of the conquering Turk, our present system works fairly well and through purely democratic means. The schools gather at least a fifth of the capable men, and feed probably half of the men of the very highest capacity into the universities. There they become mutually acquainted, are prepared to be useful in the professions and in controlling the thought and action of the masses through the press and through the educational system and by books. In some degree, although much less than could be wished, they supply the actual rulers of the state. They are impelled to strive to enter through the social prestige that attaches to being a student and to the professions themselves and are held to their tasks by hopes of the rewards that the professions offer. Distribution to the tasks for which they are fitted is not so accurate and certain as in the Ottoman regime, but here, too, there is approximation to adequacy in selection, with gradual advancement of the men who are best qualified. While this is not the only agency that acts in selecting and selection is not the only function of the school, it is sufficiently important to justify the existence of the educational system did that have no other warrant. It also must be said that it is the factor that conceals as well as atones for the faults in the functions that we ordinarily associate with education.

# THE GROUP-THEORY ELEMENT OF THE HISTORY OF MATHEMATICS

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FEW mathematical terms suggest such fundamental human cravings as the term group, and few have been more appropriately chosen. Just as human society has led to perplexities which increased with the advance of civilization so the mathematical group-theory has given rise to problems which became more and more difficult with the advances in the development of mathematics. In both cases the primitive stages are comparatively simple and their history throws important light on the later developments.

The history of the mathematical group-theory can be conveniently divided into three periods. The first of these extends from the beginning of mathematical history to about 1770 A. D., and may be called the *implicit period* since the group concept was then employed without being explicitly stated. The second, or *specialization period*, extends from about 1770 to about 1870. During this period the theory of substitution groups was founded as an autonomous science and the usefulness of this theory in the study of algebraic equations was emphasized. The third, or *generalization period*, extends from about 1870 to the present day, and is characterized by increased generalizations by abstraction and the explicit use of groups in each of the large domains of mathematics.

The most fundamental property of the elements of a group in the common restricted sense of this term is that they satisfy the condition that each group contains one and only one element which satisfies the equation

$$xy=z$$

whenever any two of these symbols are replaced by two equal or unequal elements of the group. This condition is evidently satisfied by the members of the number systems of the ancients, including the Babylonians, the Egyptians and the Greeks. On the other hand, the zero of our common modern number system destroys this group property of the entire system. If the zero is excluded the rest of these numbers (real or complex) constitute a group as regards multiplication.

One of the oldest groups of operations in the history of mathematics is the multiplication group whose elements are all the ordinary

rational numbers with the exception of zero. This group is used implicitly in the Ahmes papyrus, written about 1700 B. C., since the linear equation and fractions are found frequently in this work. It is an interesting historical fact that for many centuries after this date the ancients seemed to have considered only numbers which are elements of this group, and one is led to inquire to what extent the guiding influence of the group concept was responsible for the late introduction of zero as a number.

It might at first appear that the introduction of zero as a number tended to show that the group concept was not a fundamental guiding principle in the development of arithmetic since it failed to dominate when opposing forces presented themselves. The impression that the group concept did not dominate when zero was introduced is, however, not quite correct, since this number which was rejected by the multiplication group was destined to become the principal element, or the identity, of the addition group. "The stone which the builders rejected, the same is become the head of the corner."

It is an interesting fact that the addition group was made possible by the introduction of zero and by granting full number citizenship to the negative numbers, and the latter was done about the time when the multiplication group was somewhat impaired by the introduction of zero. These important extensions of our number system were completed during the seventeenth century but some steps in this direction had been taken a thousand years earlier especially by the Hindus. In particular, Brahmagupta had already illustrated negative and positive numbers by debts and credits and he observed that a debt subtracted from zero becomes a credit and a credit subtracted from zero becomes a debt, and if one subtracts a debt from a credit or a credit from a debt one obtains the sum.

The long delay in the general introduction of zero as a number seems to show that the ancient peoples held tenaciously to the view that all of the numbers without exception should constitute a group as regards multiplication. It is doubtless true that the group concept was not clearly observed by them and that they could not have given a satisfactory account of the motives which guided them in their efforts for more knowledge about numbers, but the fact that they were guided by this concept seems to be well established.

H. Poincaré pointed out that the same concept guided the ancients in their efforts to secure a knowledge of geometry and he noted that the absence of any direct reference to groups in Euclid's *Elements* was due to the fact that the group notions were among the oldest mathematical notions to be assimilated and hence they did not seem to require explicit mention even at the time of Euclid, notwithstanding the fact that the principal foundation of Euclid's demonstrations is really the group

and its properties.[1] In view of the fact that the group notions are so fundamental and elementary that they did not seem to require explicit mention at the time of Euclid it may at first appear strange that during the latter half of the nineteenth century these notions assumed a prominent place in the mathematical literature and that the subject of group-theory began to be regarded as one of the most difficult in the whole range of pure mathematics.

The reason for this change of attitude on the part of the mathematicians is not difficult to discover. As long as only the most general notions of groups were needed the subject was naturally regarded as too elementary to require any special attention. The idea that a set of distinct elements should have the property that any two of them can be combined into one and that this one is also found in the set was illustrated not only by the natural numbers but also by the movements of figures in space, and hence this idea became firmly fixed in the human mind at an early age. It is in accord with the human yearnings for completeness and it is a natural extension of the notion of cyclic changes which were illustrated by the daily and the seasonal apparent movements of the sun.

There is only a short step from this idea of completeness to the idea that a set of distinct elements has the property that when any two of the symbols in the equation $xy=z$ are replaced by distinct or equal elements of the set the resulting linear equation has always one and only one root in the set. If we add to these conditions the condition that the associative law shall be satisfied when the elements of the set are combined we have a complete modern definition of the term group, and it is at once apparent that this definition involves only very fundamental and elementary notions in regard to laws in the world of ideas.

While the general laws of the group are very mild they proved to require exceptions at an early stage in the growth of mathematics. As was noted above the entrance of zero into our number system required some modification of these laws as regards the operation of multiplication. The one law of combination imposed by the group notion was too narrow for the full development of our operations with numbers, where two modes of combination, now known as addition and multiplication, were developed even in prehistoric times. Historically the group concept may therefore be said to embody fundamental laws of combination with which human beings became acquainted in prehistoric times but which had to be violated in certain respects in order to secure the most fruitful mathematical developments.

[1] H. Poincaré, "On the foundations of geometry," *The Monist*, Vol. 9, (1898) p. 34.

As these laws were not formulated abstractly until about 1870 their early violators were naturally unconscious of the significance of their steps as regards the group concept. In fact, these laws might never have been formulated if it had not been discovered that without violating any of them it was possible to develop a very useful and extensive body of knowledge. The mathematical world discovered this fact by accident and at a comparatively late date. The discovery seems to have been due to the development of a large body of knowledge relating to a special class of groups now known as *substitution groups.*

The fundamental ideas involved in this body of knowledge are also very elementary. About 1770 J. L. Lagrange and others were much interested in the solution of the general equation in one unknown. More than two centuries had then elapsed since several Italian mathematicians had discovered algebraic solutions of the general cubic and the general biquadratic equation. All efforts to obtain a solution of the general quintic had failed and the mathematical world was becoming more and more deeply interested in either making further advances along this line or proving that such advances are impossible.

In the study of the methods which had led to success for the lower degrees it appeared that the number of different formal values which certain unsymmetric rational functions of a number of variables assume when these variables are permuted in every possible manner was of fundamental importance. For instance, the expression $x_1x_2+x_3x_4$ assumes the following three values

$$x_1x_2+x_3x_4,\ x_1x_3+x_2x_4,\ x_1x_4+x_2x_3$$

when the four variables $x_1$, $x_2$, $x_3$, $x_4$ are permuted in every possible manner. As there are 24 possible permutations of these four variables eight of them transform such a function into itself. These eight permutations constitute an important substitution group known as the octic group.

In general, all the permutations on $n$ variables which transform into itself a certain rational function of these variables constitute a substitution group. Hence the study of such groups seemed important for the purpose of proving the existence or the non-existence of rational functions of a given number of variables which assume a given number of values when these variables are permuted in every possible manner. The concept of a substitution group on $n$ variables is thus seen to be a very elementary one but the study of such groups led to a large body of theorems. Some of these appeared elegant even if they were supposed to apply only to a rather special field.

For about a century mathematicians studied these special groups with only occasional glimpses into their deeper meanings and wider

applications. E. Galois, A. L. Cauchy, A. Cayley, and W. R. Hamilton made references to these deeper meanings, especially as regards an abstract theory, but none of these men formulated the abstract laws governing this theory. About 1870 an eminent triumvirate of mathematicians, C. Jordan, S. Lie and F. Klein, began to exhibit the applications of the group concept to new fields. In his "Traité des Substitutions" (1870) and in an article on the groups of movements (1868) C. Jordan made fundamental geometric applications, which were greatly extended by F. Klein. About the same time S. Lie founded a new theory of continuous groups of transformations and made extensive applications of these groups in the theory of differential equations and in other mathematical subjects.

It may be of interest to note that during the first, or implicit period, of the development of our subject, groups involving an infinite number of elements exercised the greatest influence. During the second, or specialization period, the attention was centered on groups of a finite number of elements, while during the third, or generalization period, groups involving an infinite number of elements again moved to the foreground, but groups of finite order continued to receive considerable attention. Two types of groups of infinite order were studied during this period, viz., those in which the transformations were continuous and those in which these transformations were discontinuous.

The fundamental abstract notions involved in group theory are so elementary that they can be easily understood by those who are not professional mathematicians. Hence it is the more interesting that these notions were not explicitly formulated before 1870. In formulating these for the special case when the elements obey the commutative law when they are combined, L. Kronecker expressed himself as follows: "The extremely simple principles upon which the method of Gauss is founded, find applications not only in the place named but also in others, and, indeed, already in the elementary parts of the theory of numbers. This circumstance points to the fact, about which it is easy to convince oneself, that the said principles belong to a more general and more abstract sphere of ideas. Hence it appears appropriate to free their development from all non-essential limitations so that one will be spared the trouble of repeating the same method of reaching a conclusion in the different instances of its use. The advantage of this appears even in the development itself, and the presentation gains at the same time in simplicity, and, by the clear exhibition of the essentials only, also in distinctness when it is given in the most general permissible way."[2]

The student of the history of science may be especially interested in the fact that the formulation of a definition of an abstract group came so late in the development of this subject. For a full century

[2] L. Kronecker, Berlin *Monatsberichte*, 1831, p. 882.

mathematicians were dealing with special substitution groups before making a serious effort to develop an abstract theory embodying the fundamental principles of these groups as a special case. It was not until such an abstract theory was being developed that mathematicians began to see that the group concept had been a dominant factor in some of the most important early mathematical work and hence it became an important means not only for suggesting further advances but also for securing an insight into the large body of earlier mathematical developments.

A few statements found in well-known textbooks may serve to illustrate the attitude of leading mathematicians at the beginning of the present century as regards the theory of groups. In the preface of his "Géometrie," 1905, E. Borel says:

> The new foundation (of elementary geometry) has been laid in the nineteenth century by the works of leading mathematicians. It consists of the recognition that elementary geometry is equivalent to the investigation of the group of movements. Such a view is in accord with the characteristic tendency of modern scientists to replace static investigations of the phenomena by dynamic; or, to speak in more general terms, the thought of development penetrates more and more our observations.

In his "Lehrbuch der Algebra" (kleine Ausgabe), 1912, page 180, H Weber notes that:

> There are chiefly two large general concepts which dominate modern algebra. The existence and importance of these concepts could be observed only after algebra was completed to a certain extent, and had become the property of the mathematicians. Only then could be observed the combining and guiding principles. These are the concepts of groups and of domains (koerper) which we now proceed to explain. The more general of these is the concept of group.

In his "Berührungstransformationen," 1914, page 11, H. Liebmann makes the following statement:

> The rules and concept development of group theory may be compared with the organizing laws of nature according to which crystals arise. If it is allowed to continue the figure of speech it may be added that the remaining mother liquor is a rich fostering soil on which luxuriant organized life unfolds itself.

These quotations may suffice to indicate in a general way to what extent group-theory influenced the trend of mathematical progress since the beginning of the third period of its development. The infinite number of finite groups, each of which exhibits special laws of operations, which had been discovered during the second period of the development of this subject, showed that this theory can never be completely mastered in its details. There are, however, large categories of groups which have many properties in common and whose common operational laws throw light on other mathematical developments.

Comparatively little progress has been made in the study of those abstract properties which all groups have in common, yet it is just these common properties which were popularized by the mathematical literature of the last quarter of the nineteenth century. While they are so simple that the ancients did not consider it necessary to mention them

explicitly it was found that they furnish a point of view which offers many advantages. For instance, few mathematical terms are more useful than the term equivalent, and one of the services which group-theory has rendered is to give this term a flexible yet perfectly definite meaning by noting that the equivalence of two objects implies that one can be transformed into the other by the operations of a certain group.

Hence the term equivalent is relative to the group under consideration. For instance, in Euclidean geometry two figures are equivalent if they can be made to coincide by operations of the group composed of displacements and symmetries. The distance between any two points is an absolute invariant under this group. On the other hand, in elementary geometry two figures are equivalent when they can be transformed into each other by the operators of the group composed of the similarity transformations which includes the preceding group as an invariant subgroup. In elementary geometry all circles are equivalent, and all squares are equivalent, but this is not true in Euclidean geometry.

Euclid's "Elements" could have been enriched not only by the explicit use of groups of infinite order but also by the introduction of groups of finite order. In particular, the five regular solids which play an importane roôle in Greek mathematics and in Greek philosophy represent three interesting groups of finite order. In the words of E. Picard:

> A regular polyhedron, say an icosahedron, is on the one hand the solid that all the world knows; it is also, for the analyst, a group of finite order, corresponding to the divers ways of making the polyhedron coincide with itself. The investigation of all the types of groups of motion of finite order interests not only the geometers, but also the crystallographers; it goes back essentially to the study of groups of ternary linear substitutions of determinant unity, and leads to the thirty-two systems of symmetry of the crystallography for the particular complex.

While it seems impossible to establish the reasons why Euclid did not make explicit use of groups of finite and of infinite order in his "Elements," the fact that Aristotle frequently expressed the view that mathematics has to do with the *immovable* objects except such as relate to astronomy, is suggestive. While movements were used to illustrate the demonstrations of theorems the Greek philosophers seemed to hold the view that geometry itself was essentially a static subject. It is difficult to overestimate the great influence which this view had on the later history of mathematics.

If Euclid had emphasized in his "Elements" the dynamic rather than the static elements of mathematics it is likely that his work would have exerted a more vigorous influence. The cube of Euclid, for instance, is of great interest but it is not so inspiring as the cube composed of the twenty-four movements of space which leave Euclid's cube invariant. These movements affect all space and convey big and far-

reaching notions. Moreover, they suggest many questions as regards subgroups and abstract laws of operation. In particular, this group of order 24 is completely defined by the fact that it contains two operators of orders 2 and 3 respectively whose product is of order 4.

While a group-theory of the third century B. C. is conceivable it could not have been the group-theory of the nineteenth century, since the latter century had a much richer mathematical heritage. The rapid strides of group-theory during the last century were largely due to the utilization of old results as is always the case in generalizations by abstraction. The soil had been prepared by the labors of earlier centuries and it was only necessary to sow on it the new seed to secure the bountiful harvest with which the labors of many workers in this field were rewarded, especially during the last decades of the ninteenth century.

When group-theory appeared explicitly it naturally took a form which was in accord with the spirit of the times. Substitution groups constitute a type of combinatory analysis and arose about the time when the Combinatorial School flourished in Germany under the leadership of C. F. Hindenburg (1741-1808). Abstract group-theory is a type of postulational mathematics and its early development during the middle of the preceding century was in the van of the postulational activity which was so prominent during the second half of the nineteenth century. Continuous and geometric group-theory are mainly applied group-theory and their rapid development during the latter quarter of the preceding century is in accord with the spirit of this age when the fear of mathematical isolation through overspecialization tended to make the study of applications especially popular.

# THE OLDEST OF THE FORESTS

By DR. JOHN M. CLARKE

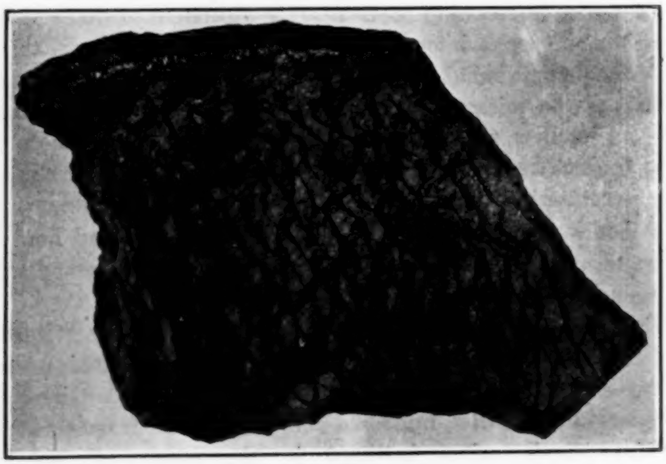
NEW YORK STATE MUSEUM, ALBANY, N. Y.

THE chief signal officer of our army, General Squier, has demonstrated the reality of what we might well have regarded an almost fanciful conception—one that might have emerged from the rosy mists when fairies had not been reduced to formulas and the notes of Pan were still to be heard in the forest aisles. The trees of the forest, says this distinguished academician, are antennae of the wireless telegraph and conductors of messages which can be interpreted by human ears if they are in human language. Their other messages, untranslatable to our ears, are left to our fancy, but the trees stand reaching their sensitive finger tips out into the sky and it would be strange indeed if they did not catch and draw down other messages which had to do with their own concerns and upbuilding. The picture is a pretty one and a legitimate fancy indeed if we let the trees in their own silent passages carry on the gossip of the woods, their conversaziones among themselves and the world of life which they shelter.

The fool hath said in his heart that we have passed the age of miracles and that all the phenomena of Nature can be reduced to terms of human understanding. But in the apostolic sense I speak even as a fool in restating so elementary a thought as that the farther we go into the exact interpretation of the facts of Nature, the more deeply the honest mind becomes impressed with the ever enlarging evidence of the miraculous, the processes in Nature which the best of human intellect can not compass or explain. Let the whole organism of the tree be put in terms of chemical and physical reactions, of tissue structure and biological explanation, and the question remains still nakedly unanswered—what is the tree, whence and how has it come, and must remain so until we apprehend the genius and spirit of the tree as well as its substance.

With this short sermon I introduce the brief story I have been asked to tell about the oldest of our forests whose remains are none the less expressive for being turned to stone. The petrified forests of the world have filled museums and homes with fragments of their beautiful woods, often brilliant in the colors of jasper and chalcedony and iridescent with the tints of the opal or their flaming

ONE OF THE SMALLER TREES FROM THE UPPER LEVEL



THE OPEN MESH OF VASCULAR BUNDLES INSIDE THE CORTICAL LAYER

heart cavities lined with crystals of amethyst, and to a mineralogist all these are only simple evidences of "replacement" by slow process of the woody tissue by silica with various coloring metallic oxides in regions where thermal and alkaline waters abound. It is easy to wave aside such beauties as these with the best explanations we have at hand, but there still remains the greater fact that these objects of our admiration are beautiful and that beauty is not explained by equations. Perhaps among all the worlds of fossil life nothing is quite so impressive to the observer as a petrified tree trunk standing erect in the rocks in the very place where it grew, its roots still running out into the underclays. It conveys a singular conviction of the fact that the embedding rocks about it are after all but the hardened muds in which it grew and which have gradually and quietly overwhelmed it, and there remains no doubt in the observer's mind that he is standing amongst the trees of an earlier order of Nature, amongst the forest groves which in their day must have heard the sound of many voices whose "stilly influences" are still stored away in those very tree trunks. Such an impression is lessened when the stony trunks are in fragments scattered about and prostrated by changes which have befallen since they turned to rock.

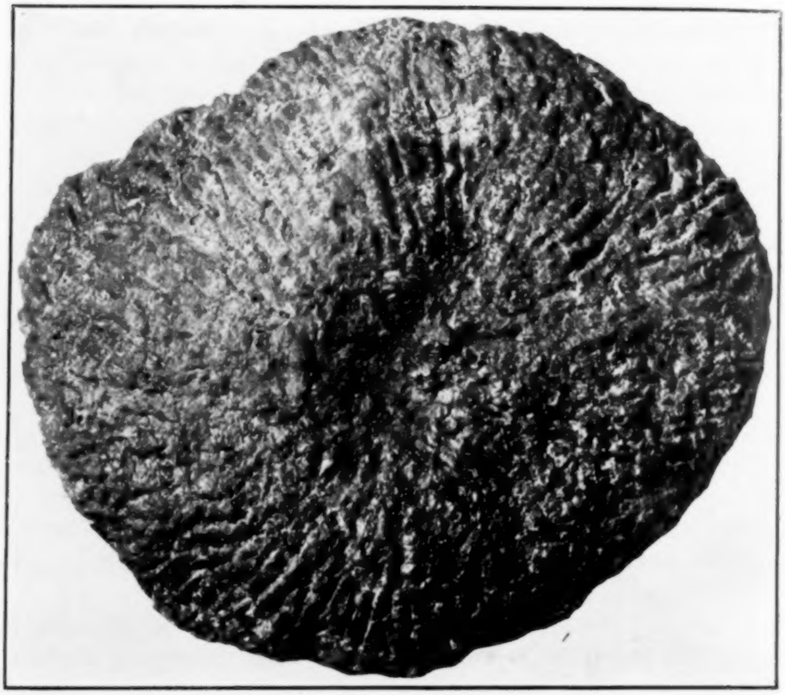
In the midst of the vast and brilliant array of disjected timber in the Arizona forests about Adamana and Holbrook and in spite of the profound impression the mind receives before this unique manifestation of Nature's procedures, the observer has nevertheless the feeling that, as has been often said, he is looking at a great petrified "timber-drive" and a timber-drive is but a raft of chopped down trees. Let the eye catch the marvellous exhibit of the Early Tertiary forests of the Yellowstone National Park, at Junction Butte, at Cache Creek and on the slopes of the Thunderer where the fossil trees stand erect to heights of 20 to 30 feet and the forest bottoms rise from one level to another over not less than fifteen different forest areas which have been buried, each in turn, by the outpourings of volcanic ashes. Here the impression is of so enormous magnitude that the mind can never release itself from the sight enforced; of an earth clothed over all its dry lands with forests giving shelter to hordes of animal life which together were working out the destinies of their evolution untouched and untrammeled by the influence of man.

If such an impression is in any way impaired it may come from the thought that these Yellowstone forests are made up of trees not very unlike those which today help to compose our northern forests. Then, as now, sequoias, other conifers and dicotyledons grew side by side. Even so the much older trees of the Arizona stone timber drives. They are of Triassic age but mostly belong to the race of Araucarian pines, still growing in the mountains of South America

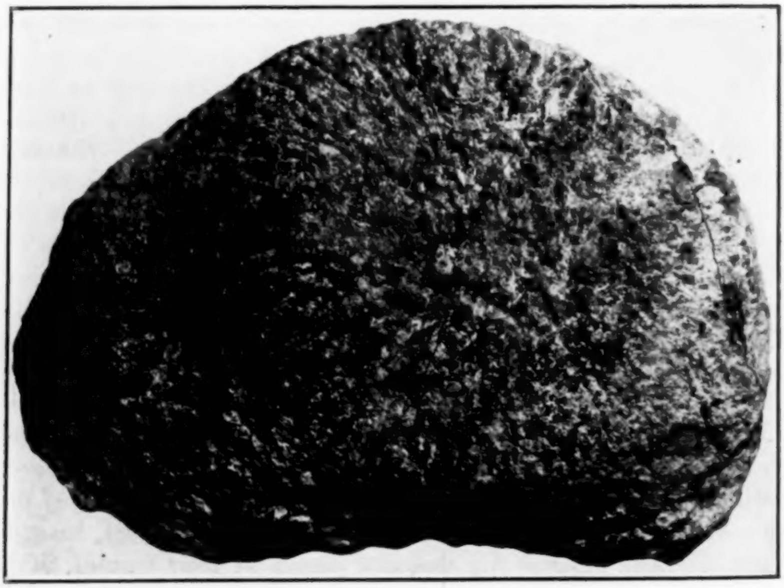
A LARGE STUMP FROM THE UPPER LEVEL. HEIGHT, 38 INCHES

and Australia. Fifty thousand feet of sediments have been laid down by the waters since these trees were growing, yet a sensation of a different order comes to the thoughtful observer who beholds in a rock wall of the Coal Period the standing trunks of Lepidodendron and Sigillaria, masters of the coal forests, which have left no descendents among the trees of the living earth. When Sir Charles Lyell in 1842 first saw the petrified Coal forest of the South Joggins, in Nova Scotia, he declared it the most wonderful phenomenon he had ever seen; trees standing perpendicular to the strata to heights of twenty-five to forty feet, piercing the beds of standstone and ending downward with their roots in the coal beds. "This subterranean forest," wrote Lyell, "exceeds in extent and quality of timber, all that have been discovered in Europe put together." The South Joggins coal forest is still on view and a really vast number of trees has been recorded from there. They rise in tier above tier in the rocks, having in their successive lives sunk below the old waters which preceded the Bay of Fundy, while the sand piled up about them and another forest grew at the old level, till all were sunk and all again raised as rocks to where they now stand.

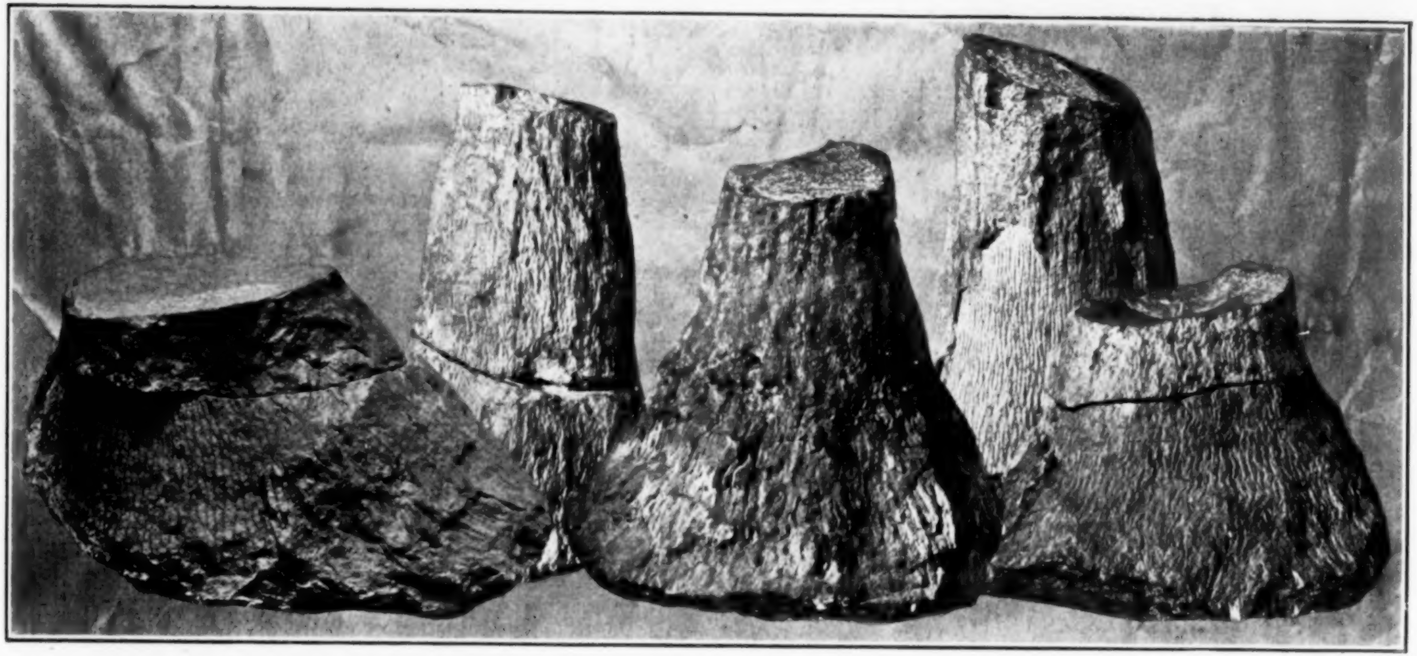
As we move still further back into the history of the earth to years when the trees were of still simpler character and a steeper topography seldom brought them into such easy reach of the recording waters as did the low and swampy sea shores of the Carboniferous period, we have been able to learn of the nature of the Devonian vegetation chiefly from the fern-like stems, Lepidodendron branches and other twigs and stipes which were carried out to sea by the flow of the rivers from the Devonian hills. The trees of the Devonian forests were not sparse and scattered. We may have come to think them so because geologists have usually happened on their remains when looking for other things among the marine deposits. The well known "Naples tree," the Archaeosigillaria, from these Devonian rocks, which rose to a height of 25 feet and is now mounted in the State Museum at Albany, is such a tree trunk carried out to sea by the flow of some forest-lined river. The rivers of the Devonian time which tore their westward way down the wooded slopes of the Old Land where the Southern New England states and their buried Atlantic remnants now lie, emptied themselves of a vast burden of sand which is now piled up to great thicknesses in the Catskill region of New York, the hills and valleys of which now bound what was the seaward edge of that ancient land. Until recently we have never quite realized the richness of these Catskill hills in the relics of the Devonian forests, but an expedition among them this year, brought into the State Museum five thousand pounds of their remains, aside from the story I am about to tell.



THE BASES OF TWO TREES FROM THE UPPER LEVEL, VIEWED FROM THE UNDERSIDE. THE ABSENCE OF ROOTS IS CLEARLY INDICATED, BUT THERE ARE TRACES OF ROOTLETS, AND THE RADIAL RIDGES SEEM TO BE CONTINUOUS WITH THE RIDGES OF THE TRUNK. DIAMETER 25 AND 38 INCHES.



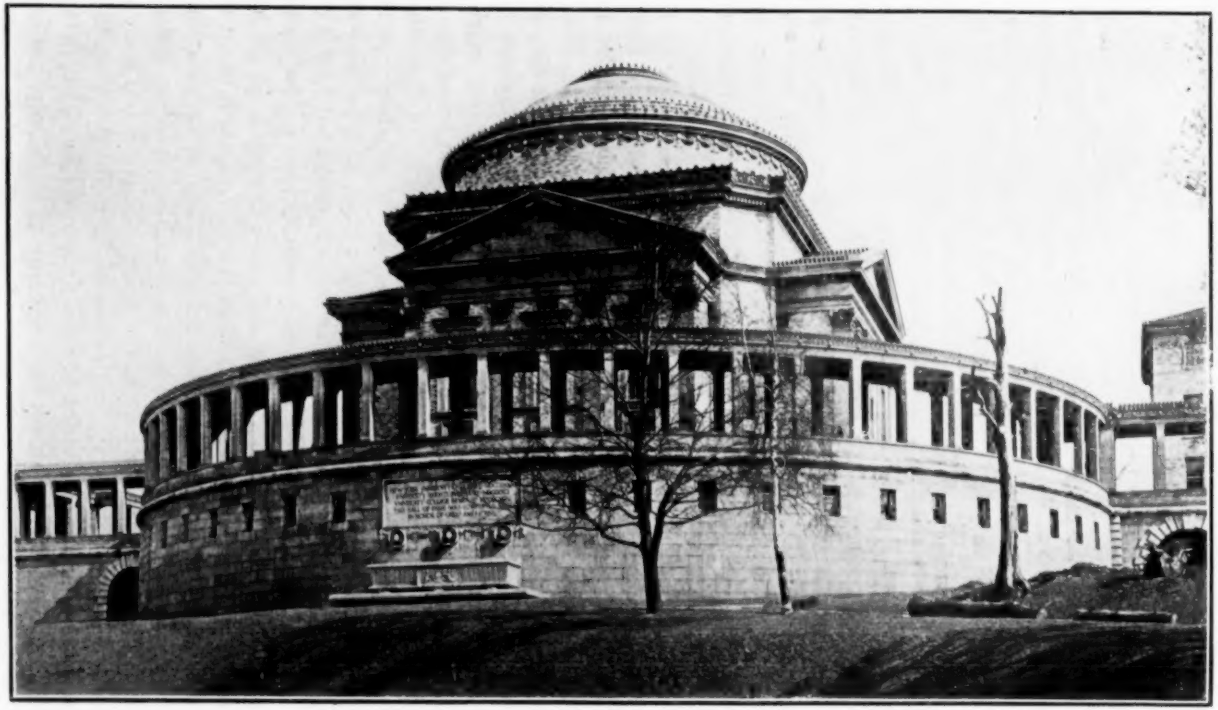
A great autumn freshet in the upper valley of the Schoharie Creek in 1869 tore out bridges, culverts and roadbeds around the little village of Gilboa where now the City of New York is impounding waters for the use of its own future citizens, and exposed in the bed rock of the hills a series of standing stumps of trees. These stumps stood all on the same level in the rocks and their rootlets ran down into the original mud in which they had grown, now turned into a dark or greenish shale. All had been cut off by some ancient flood at the same height above the base, some three or four feet; some were large and others smaller, the largest having a diameter in the shaft of two feet or more with broad expanding root-base like a flattened turnip. Thus were brought to light the standing remains of the most ancient forest growth known in the geological records in any part of the world. Ten of these tree stumps were taken out from their ancient forest, all at the same level in the rocks, and they have long constituted one of the remarkable exhibits of the vanished flora of the Devonian age. The old locality has long been deeply covered and the rocks of that level which carried these trees do not come to the surface again in the vicinity. But an effort of rediscovery made this year has been attended with unexpected results in finding the stumps of other trees of the same sort at a level sixty feet higher in the rock beds, giving evidence that the forest growths here, like the successive coal forests of the Joggins, had reappeared in the same region at a later stage in Devonian history after the first growth had been buried beneath the sea. This Schoharie Forest, earliest of all recorded forests of the earth, is of very great interest from a scientific point of view, though we are puzzled not a little to comprehend just the nature of these shore-growing woods. These trees are most nearly comparable to the tree ferns of existing tropical forests but no botanist would be content with this comparison, as they have a fructification in distinct sporangia or double purses not unlike the "keys" of a maple, quite unlike the spore-cases of the ferns: "seed-ferns" whose leaves were apparently narrow and strap-like, branching simply and rarely and terminating in these twin fruit-cases. If the diameter of the trunks is carried upward in a tapering slope these trees must have reached the very considerable height of 20-30 feet, but it is possible that the trunks broke up not so far above their base into a shrubby or bushy cap. Their real nature is still a problem for the student of fossil plants. They have been called Psaronius, but this name has not meant very much to botanists except as an expression for a fern-like plant of unsettled affinities. Now however, as the fruit of this Devonian tree is known, that and the character of its rutabaga-like base taken in connection with what have been supposed to be aerial rootlets running up the trunk, may prove the entire combination to show affinities with the cycads. But in any case we are pretty certain



SOME OF THE TREES FROM THE LOWER LEVEL, ALL FOUND AT THE SAME HORIZON. THE HEIGHT OF THE CENTRAL TRUNK IS 2 FEET, WIDTH AT BASE 22 INCHES

of having here a composition of structures wholly primitive among upstanding trees and hard to interpret in the light of existing plants. This will be disclosed in time but, whatever the nature of this primitive forest growth may prove to be, we may think of it as being almost the earliest expression of the successful effort in the plants to acquire and keep an upright position. Not long before, as geologic time is reckoned, the plants had been wholly aquatic. They had been living in the ponds of the old land and the estuaries of the coast-line. Their original home, it would seem, had been the soils of the ancient continents whence they had in a primitive day, migrated in some part into the sea itself. But the picture is presented to us now of the upward struggle toward better opportunity of growth and freer development into the all surrounding air. Dr. Berry, of Johns Hopkins, a brilliant paleobotanist, has suggested that the plants of the earth began to burst into flower at about the time the type of man, the primate, disclosed itself in the progress of life. And it may be said, I think, with the same approximation to truth that the plant sought and reached its upright position just as the vertebrate type of life became established on the earth.

At any rate our ancient New York forests afford an index to the geography of the western Catskills and the Schoharie valley during the Late Devonian Period to which they belong. We have said that the tree stumps were found in places where they grew, that the shales under them are the muds in which they were rooted and that they are preserved at at least two levels in the rocks one sixty feet above the other. Not far under the lowest forest the rocks carry true marine fossils. Tangled in the rootlets of the lower trees were found the remains of some brackish water crustaceans. These facts of themselves show that the sea which covered this region slowly withdrew and the trees crept down from the land to the water's edge, or grew over the delta plain of the fresh water streams flowing in from the old land at the east. Then for a long time the first forest must have been flooded by the waters, probably by the rising of the sea which deposited the 60 feet of overlying rocks, until another retreat of the water again brought the forest down to the shore. There was an oscillation of the coast-line, the sea rising and falling and the trees approaching, receding and approaching again toward the edge of the water. Thus the full story of this primitive forest is rich in the promise of an instructive chapter in the progress of that great division of the kingdom of life, which, though rooted and fettered from almost the beginning of its history, has kept pace in its own way with the progress of that subkingdom to which we belong.



THE HALL OF FAME OF NEW YORK UNIVERSITY

# THE PROGRESS OF SCIENCE

## SELECTIONS FOR AN AMERICAN VALHALLA

The Senate of New York University has announced the report of the official canvas of ballots received from the electors of the Hall of Fame in the fifth quinquennial election. The electorate consists of 96 men and 6 women. Ballots were received from 95 men and 6 women as follows: University and college presidents, 27; professors of history and historians, 18; scientists, 11; authors and editors, 14; high public officials and men and women of affairs, 19; actual or former justices, national or state, 12.

It was possible this year to elect to the Hall of Fame for Great Americans 20 men, and to the Hall of Fame for Great American Women, 10 women, sixty-eight votes or two-thirds of the 101 votes cast were required to elect a name unless that name bore the marking M. J. F. (more justly famous, but we are not informed in whose opinion), in which case 51 votes, or a majority of the votes cast, were required to elect. The result of the canvass showed that of the 177 names of men voted for, the following six were chosen:

MEMORIAL BUST OF HORACE MANN IN THE HALL OF FAME


MARY·CLARK·THOMPSON·MEDAL·GEOLOGIA·PALAEONTOLOGIA
OMNIA EXPLORATE BONUM·TENETE


NATIONAL ACADEMY OF SCIENCES

| Name | Class | Votes Received |
|---|---|---|
| Samuel Langhorne Clemens | I—Authors | 72 |
| James Buchanan Eads | VI—Engineers | 51 |
| Patrick Henry | XII—Statesmen | 57 |
| William Thomas Green Morton | VII—Physicians | 72 |
| Augustus Saint-Gaudens | XIV—Artists | 67 |
| Roger Williams | III—Preachers | 66 |

Of the 27 names of women voted for, the name of one woman was chosen for the Hall of Fame for Great American Women, that name bearing the M. J. F. marking and, therefore, requiring only 51 votes; the successful candidate being Alice Freeman Palmer, Educator, with 53 votes.

Prior to this election fifty men and six women had been elected to the Hall of Fame, the total now being fifty-six men and seven women. The sixth quinquennial election will take place in 1925. In the interim the Hall of Fame idea will be developed in various ways along educational lines to the end of stimulating interest in American history and inculcating reverence for our great dead. In May, 1921, there will be a public unveiling at the Hall of Fame on University Heights of twenty-six bronze tablets bearing the names of men and women who have been elected in this and previous elections, thirty-seven tablets having already been unveiled.

The votes for men of science in the recent election were as follows:

Class V—Scientists

| | |
|---|---|
| Samuel Pierpont Langley | 20 |
| Matthew Fontaine Maury | 20 |
| Samuel Newcomb | 44 |
| Benjamin Thompson | 38 |
| Scattering | 18 |
| Total | 140 |

Class VI—Engineers, Architects

| | |
|---|---|
| James Buchanan Eads | 51 |
| Henry Hobson Richardson | 11 |
| Scattering | 12 |
| Total | 74 |

Class VII—Physicians, Surgeons

| | |
|---|---|
| Charles T. Jackson | 10 |
| William T. G. Morton | 72 |
| Walter Reed | 14 |
| Benjamin Rush | 14 |
| Scattering | 14 |
| Total | 124 |

Class VIII—Inventors

| | |
|---|---|
| John Ericsson | 10 |
| Charles Goodyear | 16 |
| Cyrus Hall McCormick | 43 |
| Scattering | 22 |
| Total | 91 |

The selection of Dr. Morton as one of the sixty-two greatest Americans illustrate the inadequacy of the method of selection used by the Senate of New York University. Davy discovered the anaesthetic properties of nitrous oxide (laughing gas) in 1800, and Faraday showed that the inhalation of the vapor of ether produced anaesthetic effects in 1818. Which American physician or dentist from Dr. Godman in 1822 to Dr. Warren in 1846 deserves most credit for the introduction of anaesthetics is a question that even twenty-seven university presidents would find it difficult to decide by a majority vote.

## THE THOMPSON MEDAL FOR GEOLOGY AND PALENOTOLOGY

We give here obverse and reverse views of the medal to be awarded by the National Academy of Sciences for distinguished achievement in the sciences of Geology or Paleontology or both. The medal is established on a foundation provided by Mrs. Mary Clark Thompson of New York,

and is to be struck only in gold, the intention of the foundress being that it shall constitute a reward and recognition for work done rather than an encouragement to further achievement. The designs are the work of Theodore Spicer-Simson of New York, who has expressed on the faces of the medal the symbolism of the two sciences.

The conception of "Paleontologia" is the development and emergence of life from the rocks. The female figure portraying the attainment of life, high in promise and fertility, is struggling to release herself from her ancestral environment, the rocks of the earth, and strains upward with exalted face toward the rising sun whose beams are breaking away the mists of the morning; about the rock ledges the eternal sea is pursuing its endless work of erosion and deposition. This central device is framed by representatives of lower forms of life, the encircling margin being a graceful crinoid with its stem, the branches of its calyx merging delicately into the crests of the waves.

The reverse is a more purely conventional and simple conception expressing the outweighing importance of practical observation and determination over against the deductive and speculative treatise.

The pictures here given are the full size of the medal which it is planned to award annually and these awards will be of international scope.

## THE ENGINEERING FOUNDATION

An anonymous gift of $200,000 toward a five-million-dollar fund for the promotion of research in science and in engineering is announced by Engineering Foundation at its headquarters in the Engineering Societies Building, New York City. This contribution brings the foundation's fund to $500,000. It is the aim of the foundation to obtain one million dollars by January first.

The Engineering Foundation was organized to care for the gifts aggregating $300,000 of Ambrose Swasey, of Cleveland, Ohio, the income from these gifts being devoted to research. Since its organization as a trust fund in 1914, the funds of the foundation have been used to aid the National Research Council and others in performing research directly connected with engineering. Mr. Swasey's gifts were made to United Engineering Society as a nucleus of a large endowment "for the furtherance of research in science and in engineering, or for the advancement in any other manner of the profession of engineering and the good of mankind."

The Engineering Foundation is administered by the engineering foundation board composed of members from the American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, and American Institute of Electrical Engineers and members at large. The board is a department of United Engineering Society. It is the instrumentality of the founder societies named for the stimulation, direction and support of research.

## SCIENTIFIC ITEMS

The only scientific men of distinction whose death has been reported during the past month is Theodore Flournoy, formerly professor of physiology and psychology at the University of Geneva.

Dr. Edward Rhodes Stitt, head of the Naval Medical School at Washington, D. C., has been appointed Surgeon General of the Navy, to succeed Surgeon General Braisted, who retired on November 26.